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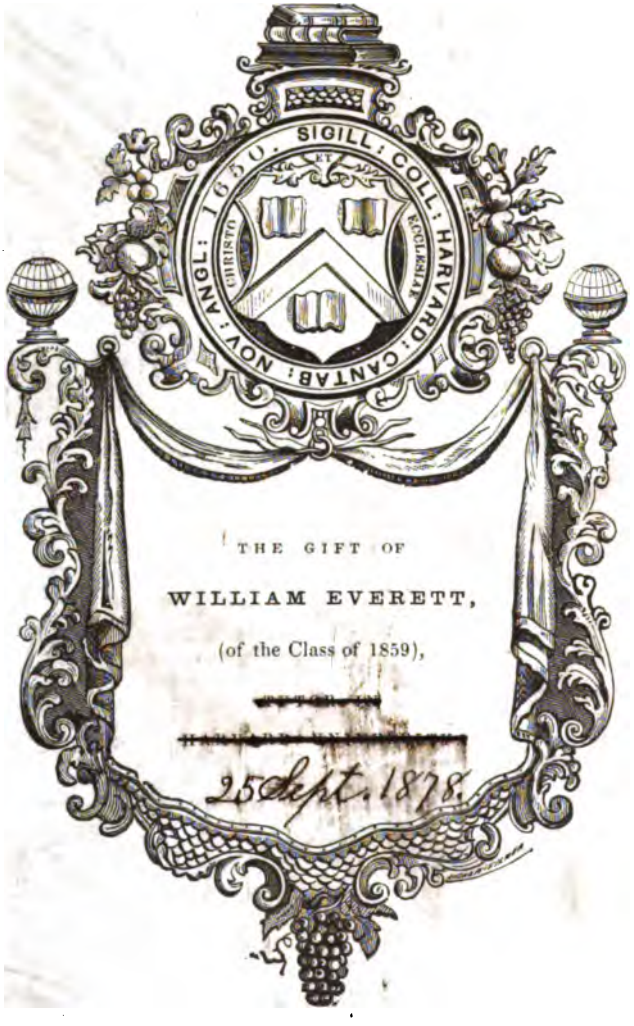

THE GIFT OF

WILLIAM EVERETT,

(of the Class of 1859),

25 dept. 1878.

Military Schools

AND

COURSES OF INSTRUCTION

IN THE

SCIENCE AND ART OF WAR,

IN

FRANCE, PRUSSIA, AUSTRIA, RUSSIA, SWEDEN, SWITZERLAND, SARDINIA, ENGLAND, AND THE UNITED STATES.

DRAWN FROM RECENT OFFICIAL REPORTS AND DOCUMENTS.

By HENRY BARNARD, LL.D.

PART I.—FRANCE AND PRUSSIA.

PHILADELPHIA:
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1862.

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1878 Sept. 25.
Prof. William Smith,
(1879)

ENTERED, according to Act of Congress, in the year 1862,

BY HENRY BARNARD,

In the Clerk's Office of the District Court of Connecticut.

MILITARY SCHOOLS AND EDUCATION.

An account of the Military and Naval Schools of different countries, with special reference to the extension and improvement, among ourselves, of similar institutions and agencies, both national and state, for the special training of officers and men for the exigencies of war, was promised by the Editor in his original announcement of "*The American Journal and Library of Education.*" Believing that the best preparation for professional and official service of any kind, either of peace or war, is to be made in the thorough culture of all manly qualities, and that all special schools should rest on the basis, and rise naturally out of a general system of education for the whole community, we devoted our first efforts to the fullest exposition of the best principles and methods of elementary instruction, and to improvements in the organization, teaching, and discipline of schools, of different grades, but all designed to give a proportionate culture of all the faculties. We have from time to time introduced the subject of Scientific Schools—or of institutions in which the principles of mathematics, mechanics, physics, and chemistry are thoroughly mastered, and their applications to the more common as well as higher arts of construction, machinery, manufactures, and agriculture, are experimentally taught. In this kind of instruction must we look for the special training of our engineers, both civil and military; and schools of this kind established in every state, should turn out every year a certain number of candidates of suitable age to compete freely in open examinations for admission to a great National School, like the Polytechnic at Paris, or the purely scientific course of the Military Academy at West Point, and then after two years of severe study, and having been found qualified by repeated examinations, semi-annual and final, by a board composed, not of honorary visitors, but of experts in each science, should pass to schools of application or training for the special service for which they have a natural aptitude and particular preparation.

The terrible realities of our present situation as a people—the fact that within a period of twelve months a million of able bodied men have been summoned to arms from the peaceful occupations of the office, the shop, and the field, and are now in hostile array, or in actual conflict, within the limits of the United States, and the no less alarming aspect of the future, arising not only from the delicate position of our own relations with foreign governments, but from the armed interference of the great Military Powers of Europe in the internal affairs of a neighboring republic, have brought up the subject of Military Schools, and Military Education, for consideration and action with an urgency which admits of no delay. Something must and will be done at once. And in reply to numerous letters for information and suggestions, and to enable those who are urging the National, State or Municipal authorities to provide additional facilities for military instruction, or who may propose to establish schools, or engraft on existing schools exercises for this purpose,—to profit by the experience of our own and other countries, in the work of training officers and men for the Art of War, we shall bring together into a single volume, "*Papers on Military Education,*" which it was our intention to publish in successive numbers of the New Series of the "*American Journal of Education.*"

This volume, as will be seen by the Contents, presents a most comprehensive survey of the Institutions and Courses of Instruction, which the chief nations of Europe have matured from their own experience, and the study of each other's improvements, to perfect their officers for every department of military and naval service which the exigences of modern warfare require, and at the same time, furnishes valuable hints for the final organization of our entire military establishments, both national and state.

We shall publish in the Part devoted to the United States, an account of the Military Academy at West Point, the Naval Academy at Newport, and other Institutions and Agencies,—State, Associated, and Individual, for Military instruction, now in existence in this country, together with several communications and suggestions which we have received in advocacy of Military Drill and Gymnastic exercises in Schools. We do not object to a moderate amount of this Drill and these exercises, properly regulated as to time and amount, and given by competent teachers. There is much of great practical value in the military element, in respect both to physical training, and moral and mental discipline. But we do not believe in the physical degeneracy, or the lack of military aptitude and spirit of the American people—at least to the extent asserted to exist by many writers on the subject. And we do not believe that any amount of juvenile military drill, any organization of cadet-corps, any amount of rifle or musket practice, or target shooting, valuable as these are, will be an adequate substitute for the severe scientific study, or the special training which a well organized system of military institutions provides for the training of officers both for the army and navy.

Our old and abiding reliance for industrial progress, social well being, internal peace, and security from foreign aggression rests on:—

I. The better Elementary education of the whole people—through better homes and better schools—through homes, such as Christianity establishes and recognizes, and schools, common because cheap enough for the poorest, and good enough for the best,—made better by a more intelligent public conviction of their necessity, and a more general knowledge among adults of the most direct modes of effecting their improvement, and by the joint action of more intelligent parents, better qualified teachers, and more faithful school officers. This first great point must be secured by the more vigorous prosecution of all the agencies and measures now employed for the advancement of public schools, and a more general appreciation of the enormous amount of stolid ignorance and half education, or mis-education which now prevails, even in states where the most attention has been paid to popular education.

II. The establishment of a System of Public High Schools in every state—far more complete than exists at this time, based on the system of Elementary Schools, into which candidates shall gain admission only after having been found qualified in certain studies by an open examination. The studies of this class of schools should be preparatory both in literature and science for what is now the College Course, and for what is now also the requirements in mathematics in the Second Year's Course at the Military Academy at West Point.

III. A system of Special Schools, either in connection with existing Colleges, or on an independent basis, in which the principles of science shall be taught with special reference to their applications to the Arts of Peace and War. Foremost in this class should stand a National School of Science, organized and conducted on the plan of the Polytechnic School of France, and preparatory to Special Military and Naval Schools.

IV. The Appointment to vacancies, in all higher Public Schools, either among teachers or pupils, and in all departments of the Public Service by Open Competitive Examination. To a diffusion of a knowledge of what has been done, is doing, or is proposed to be done in reference to these great points, the New Series of "*The American Journal of Education*," will be devoted.

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PART I

MILITARY SYSTEM AND SCHOOLS IN FRANCE.

AUTHORITIES.

THE following account of the SYSTEM OF MILITARY EDUCATION IN FRANCE, except in the case of three or four schools, where credit is given to other authorities, is taken from an English Document entitled "*Report of the Commissioners appointed* (by the Secretary of War) *to consider the best mode of reorganizing the system of Training Officers for the Scientific Corps: together with an Account of Foreign and other Military Education.*" Reference has been had, especially in the Programmes and Courses of Instruction to the original authorities referred to by the Commissioners.

I. GENERAL MILITARY ORGANIZATON OF FRANCE.
Vauchelle's Course d' Administration Militaire, 3 vols.

II. THE POLYTECHNIC.
1. Fourcy's Histoire de l'Ecole Polytechnique.
2. Décret portant l'Organisation, &c.
3. Règlement pour le Service Interieur.
4. Programme de l'Enseignement Interieur.
5. Programme des Connaissances Exigées pour Admission, &c.
6. Rapport de la Commission Mixte, 1850.
7. Répertoire de l'Ecole Polytechnique; by M. Marielle.
8. Calenders from 1833.
9. Pamphlets—by M. le Marquis de Chambray, 1836; by V. D. Bugnot, 1837; by M. Arago, 1853.

III. SCHOOL OF APPLICATION AT METZ, AND St. CYR.
Décret Impérial, &c., 1854.

IV. SCHOOL FOR THE STAFF AT PARIS.
Manuel Réglementaire a l' Usage, &c.

V. ANNUAIRE DE L'INSTRUCTION PUBLIQUE, 1860.

MILITARY SYSTEM AND SCHOOLS OF FRANCE.

I. MILITARY SYSTEM.

The French armies are composed of soldiers levied by yearly conscription for a service of seven years. Substitutes are allowed, but in accordance with a recent alteration, they are selected by the state. Private arrangements are no longer permitted; a fixed sum is paid over to the authorities, and the choice of the substitutes made by them.

The troops are officered partly from the military schools and partly by promotion from the ranks. The proportions are established by law. One-third of the commissions are reserved for the military schools, and one-third left for the promotion from the ranks. The disposal of the remaining third part is left to the Emperor.

The promotion is partly by seniority and partly by selection.

The following regulations exist as to the length of service in each rank before promotion can be given, during a period of peace:—

A second Lieutenant can not be promoted to			Lieutenant	under	2	years' service.
A Lieutenant	"	"	Captain	"	2	"
A Captain	"	"	Major	"	4	"
A Major	"	"	Lieut-Col.	"	3	"
A Lieutenant-Colonel	"	"	Colonel	"	2	"

But in time of war these regulations are not in force.

Up to the rank of captain, two-thirds of the promotion takes place according to seniority, and the other one-third by selection.

From the rank of captain to that of major (*chef de bataillon ou d'escadron*) half of the promotion is by seniority and the other half by selection, and from major upwards, it is entirely by selection.

The steps which lead to the selection are as follows:—The general officers appointed by the minister at war to make the annual inspections of the several divisions of the army of France, who are called inspectors-general, as soon as they have completed their tours of inspection, return to Paris and assemble together for the purpose of comparing their notes respecting the officers they have each seen, and thus prepare a list arranged in the order in which they recommend that the selection for promotion should be made.

We were informed that the present minister of war almost invariably promoted the officers from the head of this list, or, in other words, followed the recommendation of the inspector-general.

II. MILITARY SCHOOLS.

The principal Military Schools at present existing in France are the following:—

1. The Polytechnic School at Paris (*Ecole Impériale Polytechnique*,) preparatory to—
2. The Artillery and Engineers School of Application at Metz (*Ecole Impériale d'Application de l'Artillerie et du Génie.*)
3. The Military School at St. Cyr (*Ecole Impériale Spéciale Militaire*,) for the Infantry and Cavalry, into which the Officers' Department of the Cavalry School at Saumur has lately been absorbed.
4. The Staff School at Paris (*Ecole Impériale d'Application d'Etat Major.*)
5. The Military Orphan School (*Prytanée Impériale Militaire*) at La Flèche.
6. The Medical School (*Ecole Impériale de Médicine et de Pharmacie Militaires*) recently established in connection with the Hospital of Val-de-Grâce.
7. The School of Musketry (*Ecole Normale de Tir*) at Vincennes, founded in 1842.
8. The Gymnastic School (*Ecole Normale de Gymnastique*) near Vincennes.
9. The Music School (*Gymnase Musical.*)
10. The Regimental Schools (*Ecoles Régimentaires.*)

The military schools are under the charge of the minister of war, with whom the authorities of the schools are in direct communication.

The expenses to the state of the military schools, including the pay of the military men who are employed in connection with them, for the year 1851, are as follows:—

For Polytechnic School at Paris,	*fr.*	554,911. 91
" Artillery and Engineers School at Metz,		187,352. 06
" Infantry and Cavalry School at St. Cyr,		682,187. 35
" Cavalry School at Saumur,		196,170. 27
" Staff School at Paris,		145,349. 96
" Gymnastic School of Musketry at Vincennes,		33,211. 33
" Regimental Schools,		108,911½,30

From this sum, 2,224,542*fr.*, should be deducted 421,372*fr.* secured from paying pupils, leaving the total cost to the state to be 1,803,308*fr.*, or about $360,000, for about 2,100 pupils. The cost to the state for training an officer of Artillery and Engineers is about $1,500, and that of an officer of the Staff is about $1,400.

SUBJECTS AND METHODS OF INSTRUCTION IN MATHEMATICS,

AS PRESCRIBED FOR ADMISSION TO THE POLYTECHNIC SCHOOL OF PARIS.

BY W. M. GILLESPIE, LL.D.,

Professor of Civil Engineering in Union College.

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SUBJECTS AND METHODS OF INSTRUCTION

IN MATHEMATICS AS PRESCRIBED FOR ADMISSION TO THE POLYTECHNIC SCHOOL OF FRANCE.

"L'École Polytechnique" is too well known, by name at least, to need eulogy in this journal. Its course of instruction has long been famed for its completeness, precision, and adaptation to its intended objects. But this course had gradually lost somewhat of its symmetrical proportions by the introduction of some new subjects and the excessive development of others. The same defects had crept into the programme of the subjects of examination for admission to the school. Influenced by these considerations, the Legislative Assembly of France, by the law of June 5th, 1850, appointed a "*Commission*" to revise the programmes of admission and of internal instruction. The President of the Commission was Thenard, its "Reporter" was Le Verrier, and the other nine members were worthy to be their colleagues. They were charged to avoid the error of giving to young students, subjects and methods of instruction "too elevated, too abstract, and above their comprehension;" to see that the course prescribed should be "adapted, not merely to a few select spirits, but to average intelligences;" and to correct "the excessive development of the preparatory studies, which had gone far beyond the end desired."

The Commission, by M. Le Verrier, prepared an elaborate report of 440 quarto pages, only two hundred copies of which were printed, and these merely for the use of the authorities. A copy belonging to a deceased member of the Commission (the lamented Professor *Theodore Olivier*), having come into the hands of the present writer, he has thought that some valuable hints for our use in this country might be drawn from it, presenting as it does a precise and thorough course of mathematical instruction, adapted to any latitude, and arranged in the most perfect order by such competent authorities. He has accordingly here presented, in a condensed form, the opinions of the Commission on *the proper subjects for examination in mathematics, preparatory to admission to the Polytechnic School, and the best methods of teaching them.*

The subjects which will be discussed are Arithmetic; Geometry; Algebra; Trigonometry; Analytical Geometry; Descriptive Geometry.

I. ARITHMETIC.

A knowledge of Arithmetic is indispensable to every one. The merchant, the workman, the engineer, all need to know how to calculate with rapidity and precision. The useful character of arithmetic indicates that its methods should admit of great simplicity, and that its teaching should be most carefully freed from all needless complication. When we enter into the spirit of the methods of arithmetic, we perceive that they all flow clearly and simply from the very principles of numeration, from some precise definitions, and from certain ideas of relations between numbers, which all minds easily perceive, and which they even possessed in advance, before their teacher made them recognize them and taught them to class them in a methodical and fruitful order. We therefore believe that there is no one who is not capable of receiving, of understanding, and of enjoying well-arranged and well-digested arithmetical instruction.

But the great majority of those who have received a liberal education do not possess this useful knowledge. Their minds, they say, are not suited to the study of mathematics. They have found it impossible to bend themselves to the study of those abstract sciences whose barrenness and dryness form so striking a contrast to the attractions of history, and the beauties of style and of thought in the great poets; and so on.

Now, without admitting entirely the justice of this language, we do not hesitate to acknowledge, that the teaching of elementary mathematics has lost its former simplicity, and assumed a complicated and pretentious form, which possesses no advantages and is full of inconveniences. The reproach which is cast upon the sciences in themselves, we out-and-out repulse, and apply it only to the vicious manner in which they are now taught.

Arithmetic especially is only an instrument, a tool, the theory of which we certainly ought to know, but the practice of which it is above all important most thoroughly to possess. The methods of analysis and of mechanics, invariably lead to solutions whose applications require reduction into numbers by arithmetical calculations. We may add that the numerical determination of the final result is almost always indispensable to the clear and complete comprehension of a method ever so little complicated. Such an application, either by the more complete condensation of the ideas which it requires, or by its fixing the mind on the subject more precisely and clearly, develops a crowd of remarks which otherwise would not have been made, and it thus contributes to facilitate the comprehension of theories in such an efficacious manner

that the time given to the numerical work is more than regained by its being no longer necessary to return incessantly to new explanations of the same method.

The teaching of arithmetic will therefore have for its essential object, to make the pupils acquire the habit of calculation, so that they may be able to make an easy and continual use of it in the course of their studies. The theory of the operations must be given to them with clearness and precision; not only that they may understand the mechanism of those operations, but because, in almost all questions, the application of the methods calls for great attention and continual discussion, if we would arrive at a result in which we can confide. But at the same time every useless theory must be carefully removed, so as not to distract the attention of the pupil, but to devote it entirely to the essential objects of this instruction.

It may be objected that these theories are excellent exercises to form the mind of the pupils. We answer that such an opinion may be doubted for more than one reason, and that, in any case, exercises on useful subjects not being wanting in the immense field embraced by mathematics, it is quite superfluous to create, for the mere pleasure of it, difficulties which will never have any useful application.

Another remark we think important. It is of no use to arrive at a numerical result, if we cannot answer for its correctness. The teaching of calculation should include, as an essential condition, that the pupils should be shown how every result, deduced from a series of arithmetical operations, may always be controlled in such a way that we may have all desirable certainty of its correctness; so that, though a pupil may and must often make mistakes, he may be able to discover them himself, to correct them himself, and never to present, at last, any other than an exact result.

The *Programme* given below is made very minute to avoid the evils which resulted from the brevity of the old one. In it, the limits of the matter required not being clearly defined, each teacher preferred to extend them excessively, rather than to expose his pupils to the risk of being unable to answer certain questions. The examiners were then naturally led to put the questions thus offered to them, so to say; and thus the preparatory studies grew into excessive and extravagant development. These abuses could be remedied only by the publication of programmes so detailed, that the limits within which the branches required for admission must be restricted should be so apparent to the eyes of all, as to render it impossible for the examiners to go out of them, and thus to permit teachers to confine their instruction within them.

The new programme for arithmetic commences with the words Decimal numeration. This is to indicate that the Duodecimal numeration will not be required.

The only practical verification of Addition and Multiplication, is to recommence these operations in a different order.

The Division of whole numbers is the first question considered at all difficult. This difficulty arises from the complication of the methods by which division is taught. In some books its explanation contains twice as many reasons as is necessary. The mind becomes confused by such instruction, and no longer understands what is a demonstration, when it sees it continued at the moment when it appeared to be finished. In most cases the demonstration is excessively complicated and does not follow the same order as the practical rule, to which it is then necessary to return. There lies the evil, and it is real and profound.

The phrase of the programme, Division of whole numbers, intends that the pupil shall be required to explain the practical rule, and be able to use it in a familiar and rapid manner. We do not present any particular mode of demonstration, but, to explain our views, we will indicate how we would treat the subject if we were making the detailed programme of a *course* of arithmetic, and not merely that of an *examination*. It would be somewhat thus:

"The quotient may be found by addition, subtraction, multiplication;

"Division of a number by a number of one figure, when the quotient is less than 10;

"Division of any number by a number less than 10;

"Division of any two numbers when the quotient has only one figure;

"Division in the most general case.

"*Note.*—The practical rule may be entirely explained by this consideration, that by multiplying the divisor by different numbers, we see if the quotient is greater or less than the multiplier."

The properties of the Divisors of numbers, and the decomposition of a number into prime factors should be known by the student. But here also we recommend simplicity. The theory of the greatest common divisor, for example, has no need to be given with all the details with which it is usually surrounded, for it is of no use in practice.

The calculation of Decimal numbers is especially that in which it is indispensable to exercise students. Such are the numbers on which they will generally have to operate. It is rare that the data of a question are whole numbers; usually they are decimal numbers which are not even known with rigor, but only with a given decimal approximation; and the result which is sought is to deduce from these, other decimal numbers, themselves exact to a certain degree of approximation,

fixed by the conditions of the problem. It is thus that this subject should be taught. The pupil should not merely learn how, in one or two cases, he can obtain a result to within $\frac{1}{n}$, n being any number, but how to arrive by a practicable route to results which are exact to within a required decimal, and on the correctness of which they can depend.

Let us take decimal multiplication for an example. Generally the pupils do not know any other rule than "to multiply one factor by the other, without noticing the decimal point, except to cut off on the right of the product as many decimal figures as there are in the two factors." The rule thus enunciated is methodical, simple, and apparently easy. But, in reality, it is practically of a repulsive length, and is most generally inapplicable.

Let us suppose that we have to multiply together two numbers having each six decimals, and that we wish to know the product also to the sixth decimal. The above rule will give twelve decimals, the last six of which, being useless, will have caused by their calculation the loss of precious time. Still farther; when a factor of a product is given with six decimals, it is because we have stopped in its determination at that degree of approximation, neglecting the following decimals; whence it results that several of the decimals situated on the right of the calculated product are not those which would belong to the rigorous product. What then is the use of taking the trouble of determining them?

We will remark lastly that if the factors of the product are incommensurable, and if it is necessary to convert them into decimals before effecting the multiplication, we should not know how far we should carry the approximation of the factors before applying the above rule. It will therefore be necessary to teach the pupils the abridged methods by which we succeed, at the same time, in using fewer figures and in knowing the real approximation of the result at which we arrive.

Periodical decimal fractions are of no use. The two elementary questions of the programme are all that need be known about them.

The Extraction of the square root must be given very carefully, especially that of decimal numbers. It is quite impossible here to observe the rule of having in the square twice as many decimals as are required in the root. That rule is in fact impracticable when a series of operations is to be effected. "When a number N increases by a comparatively small quantity d, the square of that number increases very nearly as $2Nd$." It is thus that we determine the approximation with which a number must be calculated so that its square root may afterwards be obtained with the necessary exactitude. This supposes that before determining the square with all necessary precision, we have a

suitable lower limit of the value of the root, which can always be done without difficulty.

The Cube root is included in the programme. The pupils should know this; but while it will be necessary to exercise them on the extraction of the square root by numerous examples, we should be very sparing of this in the cube root, and not go far beyond the mere theory. The calculations become too complicated and waste too much time. Logarithms are useful even for the square root; and quite indispensable for the cube root, and still more so for higher roots.

When a question contains only quantities which vary in the same ratio, or in an inverse ratio, it is immediately resolved by a very simple method, known under the name of *reduction to unity*. The result once obtained, it is indispensable to make the pupils remark that it is composed of the quantity which, among the data, is of the nature of that which is sought, multiplied successively by a series of abstract ratios between other quantities which also, taken two and two, are of the same nature. Hence flows the rule for writing directly the required result, without being obliged to take up again for each question the series of reasonings. This has the advantage, not only of saving time, but of better showing the spirit of the method, of making clearer the meaning of the solution, and of preparing for the subsequent use of formulas. The consideration of "homogeneity" conduces to these results.

We recommend teachers to abandon as much as possible the use of examples in abstract numbers, and of insignificant problems, in which the data, taken at random, have no connection with reality. Let the examples and the exercises presented to students always relate to objects which are found in the arts, in industry, in nature, in physics, in the system of the world. This will have many advantages. The precise meaning of the solutions will be better grasped. The pupils will thus acquire, without any trouble, a stock of precise and precious knowledge of the world which surrounds them. They will also more willingly engage in numerical calculations, when their attention is thus incessantly aroused and sustained, and when the result, instead of being merely a dry number, embodies information which is real, useful, and interesting.

The former arithmetical programme included the theory of *progressions* and *logarithms;* the latter being deduced from the former. But the theory of logarithms is again deduced in algebra from exponents, much the best method. This constitutes an objectionable "*double emploi.*" There is finally no good reason for retaining these theories in arithmetic.

The programme retains the questions which can be solved by making two arbitrary and successive hypotheses on the desired result. It is true

that these questions can be directly resolved by means of a simple equation of the first degree; but we have considered that, since the resolution of problems by means of hypotheses, constitutes the most fruitful method really used in practice, it is well to accustom students to it the soonest possible. This is the more necessary, because teachers have generally pursued the opposite course, aiming especially to give their pupils direct solutions, without reflecting that the theory of these is usually much more complicated, and that the mind of the learner thus receives a direction exactly contrary to that which it will have to take in the end.

"Proportions" remain to be noticed.

In most arithmetics problems are resolved first by the method of "reduction to unity," and then by the theory of proportions. But beside the objection of the "*double emploi*," it is very certain that the method of reduction to unity presents, in their true light and in a complete and simple manner, all the questions of ratio which are the bases of arithmetical solutions; so that the subsequent introduction of proportions teaches nothing new to the pupils, and only presents the same thing in a more complicated manner. We therefore exclude from our programme of examination the solution of questions of arithmetic, presented under the special form which constitutes the theory of proportions.

This special form we would be very careful not to invent, if it had not already been employed. Why not say simply "The ratio of M to N is equal to that of P to Q," instead of hunting for this other form of enunciating the same idea, "M *is to* N *as* P *is to* Q"? It is in vain to allege the necessities of geometry; if we consider all the questions in which proportions are used, we shall see that the simple consideration of the equality of ratios is equally well adapted to the simplicity of the enunciation and the clearness of the demonstrations. However, since all the old books of geometry make use of proportions, we retain the properties of proportions at the end of our programme; but with this express reserve, that the examiners shall limit themselves to the simple properties which we indicate, and that they shall not demand any application of proportions to the solution of arithmetical problems.

PROGRAMME OF ARITHMETIC.

Decimal numeration.

Addition and subtraction of whole numbers.

Multiplication of whole numbers.—Table of Pythagoras.—The product of several whole numbers does not change its value, in whatever order the multiplications are effected.—To multiply a number by the product of several factors, it is sufficient to multiply successively by the factors of the product.

Division of whole numbers.—To divide a number by the product of several factors, it is sufficient to divide successively by the factors of the product.

Remainders from dividing a whole number by 2, 3, 5, 9, and 11.—Applications to the characters of divisibility by one of those numbers; to the verification of the product of several factors; and to the verification of the quotient of two numbers.

Prime numbers. Numbers prime to one another.

To find the greatest common divisor of two numbers.—If a number divides a product of two factors, and if it is prime to one of the factors, it divides the other.—To decompose a number into its prime factors.—To determine the smallest number divisible by given numbers.

Vulgar fractions.

A fraction does not alter in value when its two terms are multiplied or divided by the same number. Reduction of a fraction to its simplest expression. Reduction of several fractions to the same denominator. Reduction to the smallest common denominator.—To compare the relative values of several fractions.

Addition and subtraction of fractions.—Multiplication. Fractions of fractions.—Division.

Calculation of numbers composed of an entire part and a fraction.

Decimal numbers.

Addition and subtraction.

Multiplication and division.—How to obtain the product of the quotient to within a unit of any given decimal order.

To reduce a vulgar fraction to a decimal fraction.—When the denominator of an irreducible fraction contains other factors than 2 and 5, the fraction cannot be exactly reduced to decimals; and the quotient, which continues indefinitely, is periodical.

To find the vulgar fraction which generates a periodical decimal fraction: 1° when the decimal fraction is simply periodical; 2° when it contains a part not periodical.

System of the new measures.

Linear Measures.—Measures of surface.—Measures of volume and capacity.—Measures of weight.—Moneys.—Ratios of the principal foreign measures (England, Germany, United States of America) to the measures of France.

Of ratios. Resolution of problems.

General notions on quantities which vary in the same ratio or in an inverse ratio.—Solution, by the method called *Reduction to unity*, of the simplest questions in which such quantities are considered.—To show the homogeneity of the results which are arrived at; thence to deduce the general rule for writing directly the expression of the required solution.

Simple interest.—General formula, the consideration of which furnishes the solution of questions relating to simple interest.—Of discount, as practised in commerce.

To divide a sum into parts proportional to given numbers.

Of questions which can be solved by two arbitrary and successive hypotheses made on the desired result.

Of the square and of the square root. Of the cube and of the cube root.

Formation of the square and the cube of the sum of two numbers.—Rules for extracting the square root and the cube root of a whole number.—If this root is not entire, it cannot be exactly expressed by any number, and is called incommensurable.

Square and cube of a fraction.—Extraction of the square root and cube root of vulgar fractions.

Any number being given, either directly, or by a series of operations which permit only an approximation to its value by means of decimals, how to extract the square root or cube root of that number, to within any decimal unit.

Of the proportions called geometrical.

In every proportion the product of the extremes is equal to the product of the means.—Reciprocal proportion.—Knowing three terms of a proportion to find the fourth.—Geometrical mean of two numbers.—How the order of the terms of a proportion can be inverted without disturbing the proportion.

When two proportions have a common ratio, the two other ratios form a proportion.

In any proportion, each antecedent may be increased or diminished by its consequent without destroying the proportion.

When the corresponding terms of several proportions are multiplied together, the four products form a new proportion.—The same powers or the same roots of four numbers in proportion form a new proportion.

In a series of equal ratios, the sum of any number of antecedents and the sum of their consequents are still in the same ratio.

II. GEOMETRY.

Some knowledge of Geometry is, next to arithmetic, most indispensable to every one, and yet very few possess even its first principles. This is the fault of the common system of instruction. We do not pay sufficient regard to the natural notions about straight lines, angles, parallels, circles, etc., which the young have acquired by looking around them, and which their minds have unconsciously considered before making them a regular study. We thus waste time in giving a dogmatic form to truths which the mind seizes directly.

The illustrious *Clairaut* complains of this, and of the instruction commencing always with a great number of definitions, postulates, axioms, and preliminary principles, dry and repulsive, and followed by propositions equally uninteresting. He also condemns the profusion of self-evident propositions, saying, "It is not surprising that Euclid should give himself the trouble to demonstrate that two circles which intersect have not the same centre; that a triangle situated within another has the sum of its sides smaller than that of the sides of the triangle which contains it; and so on. That geometer had to convince obstinate sophists, who gloried in denying the most evident truths. It was therefore necessary that geometry, like logic, should then have the aid of formal reasonings, to close the mouths of cavillers; but in our day things have changed face; all reasoning about what mere good sense decides in advance is now a pure waste of time, and is fitted only to obscure the truth and to disgust the reader."

Bezout also condemns the multiplication of the number of theorems, propositions, and corollaries; an array which makes the student dizzy, and amid which he is lost. All that follows from a principle should be given in natural language as far as possible, avoiding the dogmatic form. It is true that some consider the works of Bezout deficient in rigor, but he knew better than any one what really was a demonstration. Nor do we find in the works of the great old masters less generality of views, less precision, less clearness of conception than in modern treatises. Quite the contrary indeed.

We see this in Bezout's *definition of a right line*—that it tends continually towards one and the same point; and in that of *a curved line*—that it is the trace of a moving point, which turns aside infinitely little at each step of its progress; definitions most fruitful in consequences. When we define a right line as the shortest path from one point to another, we enunciate a property of that line which is of no use for demonstrations. When we define a curved line as one which is neither straight

nor composed of straight lines, we enunciate two negations which can lead to no result, and which have no connection with the peculiar nature of the curved line. Bezout's definition, on the contrary, enters into the nature of the object to be defined, seizes its mode of being, its character, and puts the reader immediately in possession of the general idea from which are afterwards deduced the properties of curved lines and the construction of their tangents.

So too when Bezout says that, in order to form an exact idea of an angle, it is necessary to consider the movement of a line turning around one of its points, he gives an idea at once more just and more fruitful in consequences, both mathematical and mechanical, than that which is limited to saying, that the indefinite space comprised between two straight lines which meet in a point, and which may be regarded as prolonged indefinitely, is called an *angle;* a definition not very easily comprehended and absolutely useless for ulterior explanations, while that of Bezout is of continual service.

We therefore urge teachers to return, in their demonstrations, to the simplest ideas, which are also the most general; to consider a demonstration as finished and complete when it has evidently caused the truth to enter into the mind of the pupil, and to add nothing merely for the sake of silencing sophists.

Referring to our Programme of Geometry, given below, our first comments relate to the "Theory of parallels." This is a subject on which all students fear to be examined; and this being a general feeling, it is plain that it is not their fault, but that of the manner in which this subject is taught. The omission of the natural idea of the constant direction of the right line (as defined by Bezout) causes the complication of the first elements; makes it necessary for Legendre to demonstrate that all right angles are equal (a proposition whose meaning is rarely understood); and is the real source of all the pretended difficulties of the theory of parallels. These difficulties are now usually avoided by the admission of a *postulate*, after the example of Euclid, and to regulate the practice in that matter, we have thought proper to prescribe that this proposition—*Through a given point only a single parallel to a right line can be drawn*—should be admitted purely and simply, without demonstration, and as a direct consequence of our idea of the nature of the right line.

We should remark that the order of ideas in our programme supposes the properties of lines established without any use of the properties of surfaces. We think that, in this respect, it is better to follow Lacroix than Legendre.

When we prove thus that three parallels always divide two right lines into proportional parts, this proposition can be extended to the case in which the ratio of the parts is incommensurable, either by the method called *Reductio ad absurdum*, or by the method of *Limits*. We especially recommend the use of the latter method. The former has in fact nothing which satisfies the mind, and we should never have recourse to it, for it is always possible to do without it. When we have proved to the pupil that a desired quantity, X, cannot be either larger or smaller than A, the pupil is indeed forced to admit that X and A are equal; but that does not make him understand or feel why that equality exists. Now those demonstrations which are of such a nature that, once given, they disappear, as it were, so as to leave to the proposition demonstrated the character of a truth evident *à priori*, are those which should be carefully sought for, not only because they make that truth better felt, but because they better prepare the mind for conceptions of a more elevated order. The method of limits, is, for a certain number of questions, the only one which possesses this characteristic—that the demonstration is closely connected with the essential nature of the proposition to be established.

In reference to the relations which exist between the sides of a triangle and the segments formed by perpendiculars let fall from the summits, we will, once for all, recommend to the teacher, to exercise his students in making numerical applications of relations of that kind, as often as they shall present themselves in the course of geometry. This is the way to cause their meaning to be well understood, to fix them in the mind of students, and to give these the exercise in numerical calculation to which we positively require them to be habituated.

The theory of similar figures has a direct application in the art of surveying for plans (*Lever des plans*). We wish that this application should be given to the pupils in detail; that they should be taught to range out and measure a straight line on the ground; that a graphometer should be placed in their hands; and that they should use it and the chain to obtain on the ground, for themselves, all the data necessary for the construction of a map, which they will present to the examiners with the calculations in the margins.

It is true that a more complete study of this subject will have to be subsequently made by means of trigonometry, in which calculation will give more precision than these graphical operations. But some pupils may fail to extend their studies to trigonometry (the course given for the Polytechnic school having become the model for general instruction in France), and those who do will thus learn that trigonometry merely gives means of more precise calculation. This application will also be

an encouragement to the study of a science whose utility the pupil will thus begin to comprehend.

It is common to say that an angle is measured by the arc of a circle, described from its summit or centre, and intercepted between its sides. It is true that teachers add, that since a quantity cannot be measured except by one of the same nature, and since the arc of a circle is of a different nature from an angle, the preceding enunciation is only an abridgment of the proposition by which we find the ratio of an angle to a right angle. Despite this precaution, the unqualified enunciation which precedes, causes uncertainty in the mind of the pupil, and produces in it a lamentable confusion. We will say as much of the following enunciations: "A dihedral angle is measured by the plane angle included between its sides;" "The surface of a spherical triangle is measured by the excess of the sum of its three angles above two right angles," etc.; enunciations which have no meaning in themselves, and from which every trace of homogeneity has disappeared. Now that everybody is requiring that the students of the Polytechnic school should better understand the meaning of the formulas which they are taught, which requires that their homogeneity should always be apparent, this should be attended to from the beginning of their studies, in geometry as well as in arithmetic. The examiners must therefore insist that the pupils shall never give them any enunciations in which homogeneity is not preserved.

The proportionality of the circumferences of circles to their radii must be inferred *directly* from the proportionality of the perimeters of regular polygons, of the same number of sides, to their apothems. In like manner, from the area of a regular polygon being measured by half of the product of its perimeter by the radius of the inscribed circle, it must be *directly* inferred that the area of a circle is measured by half of the product of its circumference by its radius. For a long time, these properties of the circle were differently demonstrated by proving, for example, with Legendre, that the measure of the circle could not be either smaller or greater than that which we have just given, whence it had to be inferred that it must be equal to it. The "Council of improvement" finally decided that this method should be abandoned, and that the method of limits should alone be admitted, in the examinations, for demonstrations of this kind. This was a true advance, but it was not sufficient. It did not, as it should, go on to consider the circle, purely and simply, as the limit of a series of regular polygons, the number of whose sides goes on increasing to infinity, and to regard the circle as possessing every property demonstrated for polygons. Instead of this, they inscribed and circumscribed to the circle two polygons of the same number of sides, and

proved that, by the multiplication of the number of the sides of these polygons, the difference of their areas might become smaller than any given quantity, and thence, finally, deduced the measure of the area of the circle; that is to say, they took away from the method of limits all its advantage as to simplicity, by not applying it *frankly*.

We now ask that this shall cease; and that we shall no longer reproach for want of rigor, the Lagranges, the Laplaces, the Poissons, and Leibnitz, who has given us this principle: that "A curvilinear figure may be regarded as equivalent to a polygon of an infinite number of sides; whence it follows that whatsoever can be demonstrated of such a polygon, no regard being paid to the number of its sides, the same may be asserted of the curve." This is the principle for *the most simple* application of which to the measure of the circle and of the round bodies we appeal.

Whatever may be the formulas which may be given to the pupils for the determination of the ratio of the circumference to the diameter (the "Method of isoperimeters" is to be recommended for its simplicity), they must be required to perform the calculation, so as to obtain at least two or three exact decimals. These calculations, made with logarithms, must be methodically arranged and presented at the examination. It may be known whether the candidate is really the author of the papers, by calling for explanations on some of the steps, or making him calculate some points afresh.

The enunciations relating to the measurement of areas too often leave indistinctness in the minds of students, doubtless because of their form. We desire to make them better comprehended, by insisting on their application by means of a great number of examples.

As one application, we require the knowledge of the methods of surveying for content (*arpentage*), differing somewhat from the method of triangulation, used in the surveying for plans (*lever des plans*). To make this application more fruitful, the ground should be bounded on one side by an irregular curve. The pupils will not only thus learn how to overcome this practical difficulty, but they will find, in the calculation of the surface by means of trapezoids, the first application of the method of quadratures, with which it is important that they should very early become familiar. This application will constitute a new sheet of drawing and calculations to be presented at the examination.

Most of our remarks on plane geometry apply to geometry of three dimensions. Care should be taken always to leave homogeneity apparent, and to make numerous applications to the measurement of volumes.

The theory of similar polyhedrons often gives rise in the examinations of the students to serious difficulties on their part. These difficulties be-

long rather to the form than to the substance, and to the manner in which each individual mind seizes relations of position; relations always easier to feel than to express. The examiners should be content with arriving at the results enunciated in our programme, by the shortest and easiest road.

The simplicity desired cannot however be attained unless all have a common starting-point, in the definition of similar polyhedrons. The best course is assuredly to consider that theory in the point of view in which it is employed in the arts, especially in sculpture; i. e. to conceive the given system of points, M, N, P, ... to have lines passing from them through a point S, the *pole of similitude*, and prolonged beyond it to M′, N′, P′, ... so that SM′, SN′, SP′, ... are proportional to SM, SN, SP, ... Then the points M′, N′, P′, ... form a system *similar* to M, N, P, ...

The areas and volumes of the cylinder, of the cone, and of the sphere must be deduced from the areas and from the volumes of the prism, of the pyramid, and of the polygonal sector, with the same simplicity which we have required for the measure of the surface of the circle, and for the same reasons. It is, besides, the only means of easily extending to cones and cylinders with any bases whatever, right or oblique, those properties of cones and cylinders,—right and with circular bases,—which are applicable to them.

Numerical examples of the calculations, by logarithms, of these areas and volumes, including the area of a spherical triangle, will make another sheet to be presented to the examiners.

PROGRAMME OF GEOMETRY.

1. OF PLANE FIGURES.

Measure of the distance of two points.—Two finite right lines being given, to find their common measure, or at least their approximate ratio.

Of angles.—Right, acute, obtuse angles.—Angles vertically opposite are equal.

Of triangles.—Angles and sides.—The simplest cases of equality.—Elementary problems on the construction of angles and of triangles.

Of perpendiculars and of oblique lines.

Among all the lines that can be drawn from a given point to a given right line, the perpendicular is the shortest, and the oblique lines are longer in proportion to their divergence from the foot of the perpendicular.

Properties of the isosceles triangle.—Problems on tracing perpendiculars.—Division of a given straight line into equal parts.

Cases of equality of right-angled triangles.

Of parallel lines.

Properties of the angles formed by two parallels and a secant.—Reciprocally, when these properties exist for two right lines and a common secant, the two lines are parallel.*—Through a given point, to draw a right line parallel to a given right line, or cutting it at a given angle.—Equality of angles having their sides parallel and their openings placed in the same direction.

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* It will be admitted, as a postulate, that only one parallel to a given right line can pass through a given point.

Sum of the angles of a triangle.

The parts of parallels intercepted between parallels are equal, and reciprocally.

Three parallels always divide any two right lines into proportional parts. The ratio of these parts may be incommensurable.—Application to the case in which a right line is drawn, in a triangle, parallel to one of its sides.

To find a fourth proportional to three given lines.

The right line, which bisects one of the angles of a triangle, divides the opposite side into two segments proportional to the adjacent sides.

Of similar triangles.

Conditions of similitude.—To construct on a given right line, a triangle similar to a given triangle.

Any number of right lines, passing through the same point and met by two parallels, are divided by these parallels into proportional parts, and divide them also into proportional parts.—To divide a given right line in the same manner as another is divided.—Division of a right line into equal parts.

If from the right angle of a right-angled triangle a perpendicular is let fall upon the hypothenuse, 1° this perpendicular will divide the triangle into two others which will be similar to it, and therefore to each other; 2° it will divide the hypothenuse into two segments, such that each side of the right angle will be a mean proportional between the adjacent segment and the entire hypothenuse; 3° the perpendicular will be a mean proportional between the two segments of the hypothenuse.

In a right-angled triangle, the square of the number which expresses the length of the hypothenuse is equal to the sum of the squares of the numbers which express the lengths of the other two sides.

The three sides of any triangle being expressed in numbers, if from the extremity of one of the sides a perpendicular is let fall on one of the other sides, the square of the first side will be equal to the sum of the squares of the other two, *minus* twice the product of the side on which the perpendicular is let fall by the distance of that perpendicular from the angle opposite to the first side, if the angle is *acute*, and *plus* twice the same product, if this angle is *obtuse*.

Of polygons.

Parallelograms.—Properties of their angles and of their diagonals.

Division of polygons into triangles.—Sum of their interior angles.—Equality and construction of polygons.

Similar polygons.—Their decomposition into similar triangles.—The right lines similarly situated in the two polygons are proportional to the homologous sides of the polygons.—To construct, on a given line, a polygon similar to a given polygon.—The perimeters of two similar polygons are to each other as the homologous sides of these polygons.

Of the right line and the circumference of the circle.

Simultaneous equality of arcs and chords in the same circle.—The greatest arc has the greatest chord, and reciprocally.—Two arcs being given in the same circle or in equal circles, to find the ratio of their lengths.

Every right line drawn perpendicular to a chord at its middle, passes through the centre of the circle and through the middle of the arc subtended by the chord.—Division of an arc into two equal parts.—To pass the circumference of a circle through three points not in the same right line.

The tangent at any point of a circumference is perpendicular to the radius passing through that point.

The arcs intercepted in the same circle between two parallel chords, or between a tangent and a parallel chord, are equal.

Measure of angles.

If from the summits of two angles two arcs of circles be described with the same radius, the ratio of the arcs included between the sides of each angle will be the same as that of these angles.—Division of the circumference into degrees, minutes, and seconds.—Use of the protractor.

An angle having its summit placed, 1° at the centre of a circle; 2° on the circumference of that circle; 3° within the circle between the centre and the circumference; 4° without the circle, but so that its sides cut the circumference; to determine the ratio of that angle to the right angle, by the consideration of the arc included between its sides.

From a given point without a circle, to draw a tangent to that circle.

To describe, on a given line, a segment of a circle capable of containing a given angle.

To make surveys for plans. (*Lever des plans.*)

Tracing a straight line on the ground.—Measuring that line with the chain.

Measuring angles with the graphometer.—Description of it.

Drawing the plan on paper.—Scale of reduction.—Use of the rule, the triangle, and the protractor.

To determine the distance of an inaccessible object, with or without the graphometer.

Three points, A, B, C, being situated on a smooth surface and represented on a map, to find thereon the point P from which the distances A B and A C have been seen under given angles. "The problem of the three points." "The *Trilinear* problem."

Of the contact and of the intersection of circles.

Two circles which pass through the same point of the right line which joins their centres have in common only that point in which they touch; and reciprocally, if two circles touch, their centres and the point of contact lie in the same right line.

Conditions which must exist in order that two circles may intersect.

Properties of the secants of the circle.

Two secants which start from the same point without the circle, being prolonged to the most distant part of the circumference, are reciprocally proportional to their exterior segments.—The tangent is a mean proportional between the secant and its exterior segment.

Two chords intersecting within a circle divide each other into parts reciprocally proportional.—The line perpendicular to a diameter and terminated by the circumference, is a mean proportional between the two segments of the diameter.

A chord, passing through the extremity of the diameter, is a mean proportional between the diameter and the segment formed by the perpendicular let fall from the other extremity of that chord.—To find a mean proportional between two given lines.

To divide a line in extreme and mean ratio.—The length of the line being given numerically, to calculate the numerical value of each of the segments.

Of polygons inscribed and circumscribed to the circle.

To inscribe or circumscribe a circle to a given triangle.

Every regular polygon can be inscribed and circumscribed to the circle.

A regular polygon being inscribed in a circle, 1° to inscribe in the same circle a polygon of twice as many sides, and to find the length of one of the sides of the second polygon; 2° to circumscribe about the circle a regular polygon of the same number of sides, and to express the side of the circumscribed polygon by means of the side of the corresponding inscribed polygon.

To inscribe in a circle polygons of 4, 8, 16, 32.....sides.

To inscribe in a circle polygons of 3, 6, 12, 24, ...sides.

To inscribe in a circle polygons of 5, 10, 20, 40.....sides.

To inscribe in a circle polygons of 15, 30, 60.....sides.

Regular polygons of the same number of sides are similar, and their perimeters are to each other as the radii of the circles to which they are inscribed or circumscribed.—The circumferences of circles are to each other as their radii.

To find the approximate ratio of the circumference to the diameter.

Of the area of polygons and of that of the circle.

Two parallelograms of the same base and of the same height are equivalent.—Two triangles of the same base and height are equivalent.

The area of a rectangle and that of a parallelogram are equal to the product of the base by the height.—What must be understood by that enunciation.—The area of a triangle is measured by half of the product of the base by the height.

To transform any polygon into an equivalent square.—Measure of the area of a polygon.—Measure of the area of a trapezoid.

The square constructed on the hypothenuse of a right-angled triangle is equivalent to the sum of the squares constructed on the other two sides.—The squares constructed on the two sides of the right angle of a right-angled triangle and on the hypothenuse are to each other as the adjacent segments and entire hypothenuse.

The areas of similar polygons are to each other as the squares of the homologous sides of the polygons.

Notions on surveying for content (*arpentage*).—Method of decomposition into triangles.—Simpler method of decomposition into trapezoids.—Surveyor's cross.—Practical solution, when the ground is bounded, in one or more parts, by a curved line.

The area of a regular polygon is measured by half of the product of its perimeter by the radius of the inscribed circle.—The area of a circle is measured by half of the product of the circumference by the radius.—The areas of circles are to each other as the squares of the radii.

The area of a sector of a circle is measured by half of the product of the arc by the radius.—Measure of the area of a segment of a circle.

2. OF PLANES AND BODIES TERMINATED BY PLANE SURFACES.

Conditions required to render a right line and a plane respectively perpendicular.

Of all the lines which can be drawn from a given point to a given plane, the perpendicular is the shortest, and the oblique lines are longer in proportion to their divergence from the foot of the perpendicular.

Parallel right lines and planes.—Angles which have their sides parallel, and their openings turned in the same direction, are equal, although situated in different planes.

Dihedral angle.—How to measure the ratio of any dihedral angle to the right dihedral angle.

Planes perpendicular to each other.—The intersection of two planes perpendicular to a third plane, is perpendicular to this third plane.

Parallel planes.—When two parallel planes are cut by a third plane the intersections are parallel.—Two parallel planes have their perpendiculars common to both.

The shortest distance between two right lines, not intersecting and not parallel.

Two right lines comprised between two parallel planes are always divided into proportional parts by a third plane parallel to the first two.

Trihedral angle.—The sum of any two of the plane angles which compose a trihedral angle is always greater than the third.

The sum of the plane angles which form a convex polyhedral angle is always less than four right angles.

If two trihedral angles are formed by the same plane angles, the dihedral angles comprised between the equal plane angles are equal.—There may be absolute equality or simple symmetry between the two trihedral angles.

Of polyhedrons.

If two tetrahedrons have each a trihedral angle composed of equal and similarly arranged triangles, these tetrahedrons are equal. They are also equal if two faces of the one are equal to two faces of the other, are arranged in the same manner, and form with each other the same dihedral angle.

When the triangles which form two homologous trihedral angles of two tetrahedrons are similar, each to each, and similarly disposed, these tetrahedrons are similar. They are also similar if two faces of the one, making with each other the same angle as two faces of the other, are also similar to these latter, and are united by homologous sides and summits.

Similar pyramids.—A plane parallel to the base of a pyramid cuts off from it a pyramid similar to it.—To find the height of a pyramid when we know the dimension of its trunk with parallel bases.

Sections made in any two pyramids at the same distance from these summits are in a constant ratio.

Parallelopipedon.—Its diagonals.

Any polyhedron can always be divided into triangular pyramids.—Two bodies composed of the same number of equal and similarly disposed triangular pyramids, are equal.

Similar polyhedrons.

The homologous edges of similar polyhedrons are proportional; as are also the diagonals of the homologous faces and the interior diagonals of the polyhedrons.—The areas of similar polyhedrons are as the squares of the homologous edges.

Measure of volumes.

Two parallelopipedons of the same base and of the same height are equivalent in volume.

If a parallelogram be constructed on the base of a triangular prism, and on that parallelogram, taken as a base, there be constructed a parallelopipedon of the same height as the triangular prism, the volume of this prism will be half of the volume of the parallelopipedon.—Two triangular prisms of the same base and the same height are equivalent.

Two tetrahedrons of the same base and the same height are equivalent.

A tetrahedron is equivalent to the third of the triangular prism of the same base and the same height.

The volume of any parallelopipedon is equal to the product of its base by its height.—What must be understood by that enunciation.—The volume of any prism is equal to the product of its base by its height.

The volume of a tetrahedron and that of any pyramid are measured by the third of the product of the base by the height.

Volume of the truncated oblique triangular prism.

The volumes of two similar polyhedrons are to each other as the cubes of the homologous edges.

3. OF ROUND BODIES.

Of the right cone with circular base.

Sections parallel to the base.—Having the dimensions of the trunk of a cone with parallel bases, to find the height of the entire cone.

The area of a right cone is measured by half of the product of the circumference of its circular base by its side.—Area of a trunk of a right cone with parallel bases.

Volume of a pyramid inscribed in the cone.—The volume of a cone is measured by the third of the product of the area of its base by its height.*

Which of the preceding properties belong to the cone of any base whatever?

Of the right cylinder with circular base.

Sections parallel to the base.

The area of the convex surface of the right cylinder is measured by the product of the circumference of its base by its height.—This is also true of the right cylinder of any base.

Measure of the volume of a prism inscribed in the cylinder.—The volume of a right cylinder is measured by the product of the area of its base by its height.—This is also true of any cylinder, right or oblique, of any base whatever.

Of the sphere.

Every section of the sphere, made by a plane, is a circle.—Great circles and small circles.

In every spherical triangle any one side is less than the sum of the other two. The shortest path from one point to another, on the surface of the sphere, is the arc of a great circle which joins the two given points.

The sum of the sides of a spherical triangle, or of any spherical polygon, is less than the circumference of a great circle.

Poles of an arc of a great or small circle.—They serve to trace arcs of circles on the sphere.

Every plane perpendicular to the extremity of a radius is tangent to the sphere.

Measure of the angle of two arcs of great circles.

Properties of the polar or supplementary triangle.

Two spherical triangles situated on the same sphere, or on equal spheres, are equal in all their parts, 1° when they have an equal angle included between sides respectively equal; 2° when they have an equal side adjacent to two angles respectively equal; 3° when they are mutually equilateral; 4° when they are mutually equiangular. In these different cases the triangles may be equal, or merely symmetrical.

The sum of the angles of any spherical triangle is less than six, and greater than two, right angles.

The lune is to the surface of the sphere as the angle of that lune is to four right angles.

Two symmetrical spherical triangles are equivalent in surface.

The area of a spherical triangle is to that of the whole sphere as the excess of the sum of its angles above two right angles is to eight right angles.

When a portion of a regular polygon, inscribed in the generating circle of the sphere, turns around the diameter of that circle, the convex area engendered is measured by the product of its height by the circumference of the circle inscribed in the generating polygon.—The volume of the corresponding polygonal sector is measured by the area thus described, multiplied by the third of the radius of the inscribed circle.

The surface of a spherical zone is equal to the height of that zone multiplied by the circumference of a great circle.—The surface of the sphere is quadruple that of a great circle.

Every spherical sector is measured by the zone which forms its base, multiplied by the third of the radius. The whole sphere is measured by its surface multiplied by the third of its radius.†

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* The volume of the cone is derived from that of the pyramid; and it is to be noted that the demonstration applies to the cone with closed base, whatever the figure of that base.

† Numerical examples on the areas and volumes of the round bodies, including the area of a spherical triangle, will be required by the examiners. The calculations will be made by logarithms.

III. ALGEBRA.

ALGEBRA is not, as are Arithmetic and Geometry, indispensable to every one. It should be very sparingly introduced into the general education of youth, and we would there willingly dispense with it entirely, excepting logarithms, if this would benefit the study of arithmetic and geometry. The programme of it which we are now to give, considers it purely in view of its utility to engineers, and we will carefully eliminate every thing not necessary for them.

Algebraical calculation presents no serious difficulty, when its students become well impressed with this idea, that every letter represents a number; and particularly when the consideration of negative quantities is not brought in at the outset and in an absolute manner. These quantities and their properties should not be introduced except as the solution of questions by means of equations causes their necessity to be felt, either for generalizing the rules of calculation, or for extending the meaning of the formulas to which it leads. CLAIRAUT pursues this course. He says, "I treat of the multiplication of negative quantities, that dangerous shoal for both scholars and teachers, only after having shown its necessity to the learner, by giving him a problem in which he has to consider negative quantities independently of any positive quantities from which they are subtracted. When I have arrived at that point in the problem where I have to multiply or divide negative quantities by one another, I take the course which was undoubtedly taken by the first analysts who have had those operations to perform and who have wished to follow a perfectly sure route: I seek for a solution of the problem which does not involve these operations; I thus arrive at the result by reasonings which admit of no doubt, and I thus see what those products or quotients of negative quantities, which had given me the first solution, must be." BEZOUT proceeds in the same way.

We recommend to teachers to follow these examples; not to speak to their pupils about negative quantities till the necessity of it is felt, and

* The true distinction between ALGEBRA and ARITHMETIC is so commonly overlooked that it may be well to present it here, in the words of Comte. "The complete solution of every question of calculation is necessarily composed of two successive parts, which have essentially distinct natures. In the first, the object is to *transform* the proposed equations, so as to make apparent the manner in which the unknown quantities are formed by the known ones; it is this which constitutes the *Algebraic* question. In the second, our object is *to find the value* of the formulas thus obtained; that is, to determine directly the values of the numbers sought, which are already represented by certain explicit functions of given numbers; this is the *Arithmetical* question. Thus the stopping-point of the algebraic part of the solution becomes the starting-point of the arithmetical part.

"ALGEBRA may therefore be defined as having for its object the *resolution of equations*; taking this expression in its full logical meaning, which signifies the transformation of *implicit* functions into equivalent *explicit* ones. In the same way ARITHMETIC may be defined as intended for *the determination of the values of functions*. Henceforth, therefore, we may call ALGEBRA *the Calculus of Functions*, and ARITHMETIC *the Calculus of Values*."

when they have become familiar with algebraic calculation; and above all not to lose precious time in obscure discussions and demonstrations, which the best theory will never teach students so well as numerous applications.

It has been customary to take up again, in algebra, the calculus of fractions, so as to generalize the explanations given in arithmetic, since the terms of literal fractions may be any quantities whatsoever. Rigorously, this may be well, but to save time we omit this, thinking it better to employ this time in advancing and exercising the mind on new truths, rather than in returning continually to rules already given, in order to imprint a new degree of rigor on their demonstration, or to give them an extension of which no one doubts.

The study of numerical equations of the first degree, with one or several unknown quantities, must be made with great care. We have required the solution of these equations to be made by the method of *substitution*. We have done this, not only because this method really comprehends the others, particularly that of *comparison*, but for this farther reason. In treatises on algebra, those equations alone are considered whose numerical coefficients and solutions are very simple numbers. It then makes very little difference what method is used, or in what order the unknown quantities are eliminated. But it is a very different thing in practice, where the coefficients are complicated numbers, given with decimal parts, and where the numerical values of these coefficients may be very different in the same equation, some being very great and some very small. In such cases the method of *substitution* can alone be employed to advantage, and that with the precaution of taking the value of the unknown quantity to be eliminated from that equation in which it has relatively the greatest coefficient. Now the method of *comparison* is only the method of substitution put in a form in which these precautions cannot be observed, so that in practice it will give bad results with much labor.

The candidates must present to the examiners the complete calculations of the resolution of four equations with four unknown quantities, made with all the precision permitted by the logarithmic tables of Callet, and the proof that that precision has been obtained. The coefficients must contain decimals and be very different from one another, and the elimination must be effected with the above precautions.

The teaching of the present day disregards too much the applicability of the methods given, provided only that they be elegant in their form; so that they have to be abandoned and changed when the pupils enter on practice. This disdain of practical utility was not felt by our great mathematicians, who incessantly turned their attention towards applica-

tions. Thus the illustrious Lagrange made suggestions like those just given; and Laplace recommended the drawing of curves for solving directly all kinds of numerical equations.

As to literal equations of the first degree, we call for formulas sufficient for the resolution of equations of two or three unknown quantities. Bezout's method of elimination must be given as a first application of that fruitful method of indeterminates. The general discussion of formulas will be confined to the case of two unknown quantities. The discussion of three equations with three unknown quantities, x, y, and z, in which the terms independent of the unknown quantities are null, will be made directly, by this simple consideration that the system then really includes only two unknown quantities, to wit, the ratios of x and y, for example, to z.

The resolution of inequalities of the first degree with one or more unknown quantities, was added to equations of the first degree some years ago. We do not retain that addition.

The equations of the second degree, like the first, must be very carefully given. In dwelling on the case where the coefficient of x^2 converges towards zero, it will be remarked that, when the coefficient is very small, the ordinary formula would give one of the roots by the difference of two numbers almost equal; so that sufficient exactness could not be obtained without much labor. It must be shown how that inconvenience may be avoided.

It is common to meet with expressions of which the maximum or the minimum can be determined by the consideration of an equation of the second degree. We retain the study of them, especially for the benefit of those who will not have the opportunity of advancing to the general theory of maxima and minima.

The theory of the algebraic calculation of imaginary quantities, given *à priori*, may, on the contrary, be set aside without inconvenience. It is enough that the pupils know that the different powers of $\sqrt{-1}$ continually reproduce in turn one of these four values, ± 1, $\pm\sqrt{-1}$. We will say as much of the calculation of the algebraic values of radicals, which is of no use. The calculation of their *arithmetical* values will alone be demanded. In this connection will be taught the notation of fractional exponents and that of negative exponents.

The theory of numbers has taken by degrees a disproportionate development in the examinations for admission; it is of no use in practice, and, besides, constitutes in the pure mathematics a science apart.

The theory of continued fractions at first seems more useful. It is employed in the resolution of algebraic equations, and in that of the ex-

ponential equation $a^x = b$. But these methods are entirely unsuited to practice, and we therefore omit this theory.

The theory of series, on the contrary, claims some farther developments. Series are continually met with in practice; they give the best solutions of many questions, and it is indispensable to know in what circumstances they can be safely employed.

We have so often insisted on the necessity of teaching students to calculate, as to justify the extent of the part of the programme relating to logarithms. We have suppressed the inapplicable method of determining logarithms by continued fractions, and have substituted the employment of the series which gives the logarithm of $n+1$, knowing that of n. To exercise the students in the calculation of the series, they should be made to determine the logarithms of the numbers from 1 to 10, from 101 to 110, and from 10,000 to 10,010, the object of these last being to show them with what rapidity the calculation proceeds when the numbers are large; the first term of the series is then sufficient, the variations of the logarithms being sensibly proportional to the variations of the numbers, within the limits of the necessary exactness. In the logarithmic calculations, the pupils will be exercised in judging of the exactness which they may have been able to obtain: the consideration of the numerical values of the proportional parts given in the tables is quite sufficient for this purpose, and is beside the only one which can be employed in practice.

The use of the sliding rule, which is merely an application of logarithms, gives a rapid and portable means of executing approximately a great number of calculations which do not require great exactness. We desire that the use of this little instrument should be made familiar to the candidates. This is asked for by all the professors of the "School of application," particularly those of Topography, of Artillery, of Construction, and of Applied Mechanics, who have been convinced by experience of the utility of this instrument, which has the greatest possible analogy with tables of logarithms.

Before entering on the subjects of higher algebra, it should be remembered that the reductions of the course which we have found to be so urgent, will be made chiefly on it. The general theory of equations has taken in the examinations an abnormal and improper development, not worth the time which it costs the students. We may add, that it is very rare to meet a numerical equation of a high degree requiring to be resolved, and that those who have to do this, take care not to seek its roots by the methods which they have been taught. These methods moreover are not applicable to transcendental equations, which are much more frequently found in practice.

The theory of the greatest common algebraic divisor, in its entire generality, is of no use, even in pure science, unless in the elimination between equations of any degree whatever. But this last subject being omitted, the greatest common divisor is likewise dispensed with.

It is usual in the general theory of algebraic equations to consider the derived polynomials of entire functions of x. These polynomials are in fact useful in several circumstances, and particularly in the theory of equal roots; and in analytical geometry, they serve for the discussion of curves and the determination of their tangents. But since transcendental curves are very often encountered in practice, we give in our programme the calculation of the derivatives of algebraic and fractional functions, and transcendental functions, logarithmic, exponential, and circular. This has been long called for, not only because it must be of great assistance in the teaching of analytical geometry, but also because it will facilitate the elementary study of the infinitesimal calculus.

We have not retrenched any of the general ideas on the composition of an entire polynomial by means of factors corresponding to its roots. We retain several theorems rather because they contain the germs of useful ideas than because of their practical utility, and therefore wish the examiners to restrict themselves scrupulously to the programme.

The essential point in practice is to be able to determine conveniently an incommensurable root of an algebraic or transcendental equation, when encountered. Let us consider first an algebraic equation.

All the methods which have for their object to separate the roots, or to approximate to them, begin with the substitution of the series of consecutive whole numbers, in the first member of the equation. The direct substitution becomes exceedingly complicated, when the numbers substituted become large. It may be much shortened, however, by deducing the results from one another by means of their differences, and guarding against any possibility of error, by verifying some of those results, those corresponding to the numbers easiest to substitute, such as ± 10, ± 20. The teacher should not fail to explain this to his pupils.

Still farther: let us suppose that we have to resolve an equation of the third degree, and that we have recognized by the preceding calculations the necessity of substituting, between the numbers 2 and 3, numbers differing by a tenth, either for the purpose of continuing to effect the separation of the roots, or to approximate nearer to a root comprised between 2 and 3. If we knew, for the result corresponding to the substitution of 2, the first, second, and third differences of the results of the new substitutions, we could thence deduce those results themselves with as much simplicity, as in the case of the whole numbers. The new third difference, for example, will be simply the thousandth part of the old

third difference. We may also remark that there is no possibility of error, since, the numbers being deduced from one another, when we in this way arrive at the result of the substitution of 3, which has already been calculated, the whole work will thus be verified.

Let us suppose again that we have thus recognized that the equation has a root comprised between 2.3 and 2.4; we will approximate still nearer by substituting intermediate numbers, differing by 0.01, and employing the course just prescribed. As soon as the third differences can be neglected, the calculation will be finished at once, by the consideration of an equation of the second degree; or, if it is preferred to continue the approximations till the second differences in their turn may be neglected, the calculation will then be finished by a simple proportion.

When, in a transcendental equation $f(X)=0$, we have substituted in $f(X)$ equidistant numbers, sufficiently near to each other to allow the differences of the results to be neglected, commencing with a certain order, the 4th, for example, we may, within certain limits of x, replace the transcendental function by an algebraic and entire function of x, and thus reduce the search for the roots of $f(X)=0$ to the preceding theory.

Whether the proposed equation be algebraic or transcendental, we can thus, when we have obtained one root of it with a suitable degree of exactness, continue the approximation by the method of Newton.

PROGRAMME OF ALGEBRA.

Algebraic calculation.

Addition and subtraction of polynomials.—Reduction of similar terms.

Multiplication of monomials.—Use of exponents.—Multiplication of polynomials. Rule of the signs.—To arrange a polynomial.—Homogeneous polynomials.

Division of monomials. Exponent *zero*.—Division of polynomials. How to know if the operation will not terminate.—Division of polynomials when the dividend contains a letter which is not found in the divisor.

Equations of the first degree.

Resolution of numerical equations of the first degree with one or several unknown quantities by the method of substitution.—Verification of the values of the unknown quantities and of the degree of their exactness.

Of cases of impossibility or of indetermination.

Interpretation of negative values.—Use and calculation of negative quantities.

Investigation of general formulas for obtaining the values of the unknown quantities in a system of equations of the first degree with two or three unknown quantities.—Method of Bezout.—Complete discussion of these formulas for the case of two unknown quantities.—Symbols $\frac{m}{o}$ and $\frac{o}{o}$.

Discussion of three equations with three unknown quantities, in which the terms independent of the unknown quantities are null.

Equations of the second degree with one unknown quantity.

Calculus of radicals of the second degree.

Resolution of an equation of the second degree with one unknown quantity.—Double solution.—Imaginary values.

When, in the equation $ax^2+bx+c=0$, a converges towards 0, one of the roots increases indefinitely.—Numerical calculation of the two roots, when a is very small.

Decomposition of the trinomial x^2+px+q into factors of the first degree.—Relations between the coefficients and the roots of the equation $x^2+px+q=0$.

Trinomial equations reducible to the second degree.

Of the maxima and minima which can be determined by equations of the second degree.

Calculation of the *arithmetical* values of radicals.

Fractional exponents.—Negative exponents.

Of series.

Geometrical progressions.—Summation of the terms.

What we call a series.—Convergence and divergence.

A geometrical progression is convergent, when the ratio is smaller than unity; diverging, when it is greater.

The terms of a series may decrease indefinitely and the series not be converging.

A series, all the terms of which are positive, is converging, when the ratio of one term to the preceding one tends towards a *limit* smaller than unity, in proportion as the index of the rank of that term increases indefinitely.—The series is diverging when this *limit* is greater than unity. There is uncertainty when it is equal to unity.

In general, when the terms of a series decrease indefinitely, and are alternately positive and negative, the series is converging.

Combinations, arrangements, and permutations of m letters, when each combination must not contain the same letter twice.

Development of the entire and positive powers of a binomial.—General terms.

Development of $(a+b\sqrt{-1})^m$.

Limit towards which $\left(1+\frac{1}{m}\right)^m$ tends, when m increases indefinitely.

Summation of piles of balls.

Of logarithms and of their uses.

All numbers can be produced by forming all the powers of any positive number, greater or less than *one*.

General properties of logarithms.

When numbers are in geometrical progression, their logarithms are in arithmetical progression.

How to pass from one system of logarithms to another system.

Calculation of logarithms by means of the series which gives the logarithm of $n+1$, knowing that of n.—Calculation of Napierian logarithms.—To deduce from them those of Briggs. Modulus.

Use of logarithms whose base is 10.—Characteristics.—Negative characteristics. Logarithms entirely negative are not used in calculation.

A number being given, how to find its logarithm in the tables of Callet. A logarithm being given, how to find the number to which it belongs.—Use of the proportional parts.—Their application to appreciate the exactness for which we can answer.

Employment of the sliding rule.

Resolution of exponential equations by means of logarithms.

Compound interest. Annuities.

Derived functions.

Development of an entire function F $(x+h)$ of the binomial $(x+h)$.—Derivative of an entire function.—To return from the derivative to the function.

The derivative of a function of x is the limit towards which tends the ratio of the increment of the function to the increment h of the variable, in proportion as h tends towards zero.

Derivatives of trigonometric functions.

Derivatives of exponentials and of logarithms.

Rules to find the derivative of a sum, of a product, of a power, of a quotient of functions of x, the derivatives of which are known.

Of the numerical resolution of equations.

Changes experienced by an entire function $f(x)$ when x varies in a continuous manner.—When two numbers a and b substituted in an entire function $f(x)$ give results with contrary signs, the equation $f(x)=0$ has at least one real root not comprised between a and b. This property subsists for every species of function which remains continuous for all the values of x comprised between a and b.

An algebraic equation of uneven degree has at least one real root.—An algebraic equation of even degree, whose last term is negative, has at least two real roots.

Every equation $f(x)=0$, with coefficients either real or imaginary of the form $a+b\sqrt{-1}$, admits of a real or imaginary root of the same form. [Only the enunciation, and not the demonstration of this theorem, is required.]

If a is a root of an algebraic equation, the first member is divisible by $x-a$. An algebraic equation of the m^{th} degree has always m roots real or imaginary, and it cannot admit more.—Decomposition of the first members into factors of the first degree. Relations between the coefficients of an algebraic equation and its roots.

When an algebraic equation whose coefficients are real, admits an imaginary root of the form $a+b\sqrt{-1}$, it has also for a root the conjugate expression $a-b\sqrt{-1}$.

In an algebraic expression, complete or incomplete, the number of the positive roots cannot surpass the number of the variations; consequence, for negative roots.

Investigation of the product of the factors of the first degree common to two entire functions of x.—Determination of the roots common to two equations, the first members of which are entire functions of the unknown quantity.

By what character to recognize that an algebraic equation has equal roots.—How we then bring its resolution to that of several others of lower degree and of unequal roots.

Investigation of the commensurable roots of an algebraic equation with entire coefficients.

When a series of equidistant numbers is substituted in an entire function of the m^{th} degree, and differences of different orders between the results are formed, the differences of the m^{th} order are constant.

Application to the separation of the roots of an equation of the third degree.—Having the results of the substitution of -1, 0, and $+1$, to deduce therefrom, by means of differences, those of all other whole numbers, positive or negative.—The progress of the calculation leads of itself to the limits of the roots.—Graphical representation of this method.

Substitution of numbers equidistant *by a tenth*, between two consecutive whole numbers, when the inspection of the first results has shown its necessity.—This substitution is effected directly, or by means of new differences deduced from the preceding.

How to determine, in continuing the approximation towards a root, at what moment the consideration of the first difference is sufficient to give that root with all desirable exactness, by a simple proportion.

The preceding method becomes applicable to the investigation of the roots of a transcendental equation $X=0$, when there have been substituted in the first member, numbers equidistant and sufficiently near to allow the differences of the results to be considered as constant, starting from a certain order.—Formulas of interpolation.

Having obtained a root of an algebraic or transcendental equation, with a certain degree of approximation, to approximate still farther by the method of Newton.

Resolution of two numerical equations of the second degree with two unknown quantities.

Decomposition of rational fractions into simple fractions.

IV. TRIGONOMETRY.

In explaining the use of trigonometrical tables, the pupil must be able to tell with what degree of exactness an angle can be determined by the logarithms of any of its trigonometrical lines. The consideration of the proportional parts will be sufficient for this. It will thus be seen that if the *sine* determines perfectly a small angle, the degree of exactness, which may be expected from the use of that line, diminishes as the angle increases, and becomes quite insufficient in the neighborhood of 90 degrees. It is the reverse for the *cosine*, which may serve very well to represent an angle near 90 degrees, while it would be very inexact for small angles. We see, then, that in our applications, we should distrust those formulas which give an angle by its sine or cosine. The *tangent*

being alone exempt from these difficulties, we should seek, as far as possible, to resolve all questions by means of it. Thus, let us suppose that we know the hypothenuse and one of the sides of a right-angled triangle, the direct determination of the included angle will be given by a cosine, which will be wanting in exactness if the hypothenuse of the triangle does not differ much from the given side. In that case we should begin by calculating the third side, and then use it with the first side to determine the desired angle by means of its tangent. When two sides of a triangle and the included angle are given, the tangent of the half difference of the desired angles may be calculated with advantage; but we may also separately determine the tangent of each of them. When the three sides of a triangle are given, the best formula for calculating an angle, and the only one never at fault, is that which gives the tangent of half of it.

The surveying for plans, taught in the course of Geometry, employing only graphical methods of calculation, did not need any more accurate instruments than the chain and the graphometer; but now that trigonometry furnishes more accurate methods of calculation, the measurements on the ground require more precision. Hence the requirement for the pupil to measure carefully a base, to use telescopes, verniers, etc., and to make the necessary calculations, the ground being still considered as plane. But as these slow and laborious methods can be employed for only the principal points of the survey, the more expeditious means of the plane-table and compass will be used for the details.

In spherical trigonometry, all that will be needed in geodesy should be learned before admission to the school, so that the subject will not need to be again taken up. We have specially inscribed in the programme the relations between the angles and sides of a right-angled triangle, which must be known by the students; they are those which occur in practice. In tracing the course to be pursued in the resolution of the three cases of any triangles, we have indicated that which is in fact employed in the applications, and which is the most convenient. As to the rest, ambiguous cases never occur in practice, and therefore we should take care not to speak of them to learners.

In surveying, spherical trigonometry will now allow us to consider cases in which the signals are not all in the same plane, and to operate on uneven ground, obtain its projection on the plane of the horizon, and at the same time determine differences of level.

It may be remarked that Descriptive Geometry might supply the place of spherical trigonometry by a graphical construction, but the degree of exactitude of the differences of level thus obtained would be insufficient.

PROGRAMME OF TRIGONOMETRY.

1. PLANE TRIGONOMETRY.

Trigonometrical lines.—Their ratios to the radius are alone considered.—Relations of the trigonometric lines of the same angle.—Expressions of the sine and of the cosine in functions of the tangent.

Knowing the sines and the cosines of two arcs a and b, to find the sine and the cosine of their sum and of their difference.—To find the tangent of the sum or of the difference of two arcs, knowing the tangents of those arcs.

Expressions for sin. $2a$ and sin. $3a$; cos. $2a$ and cos. $3a$; tang. $2a$ and tang. $3a$.

Knowing sin. a or cos. a, to calculate sin. $\frac{1}{2}a$ and cos. $\frac{1}{2}a$.

Knowing tang. a, to calculate tang. $\frac{1}{2}a$.

Knowing sin. a, to calculate sin. $\frac{1}{3}a$.—Knowing cos. a, to calculate cos. $\frac{1}{3}a$.

Use of the formula $\cos. p + \cos. q = 2\cos. \frac{1}{2}(p+q)\cos. \frac{1}{2}(p-q)$, to render logarithms applicable to the sum of two trigonometrical lines, sines or cosines.—To render logarithms applicable to the sum of two tangents.

Construction of the trigonometric tables.

Use in detail of the tables of Callet.—Appreciation, by the proportional parts, of the degree of exactness in the calculation of the angles.—Superiority of the tangent formulas.

Resolution of triangles.

Relations between the angles and the sides of a right-angled triangle, or of any triangle whatever.—When the three angles of a triangle are given, these relations determine only the ratios of the sides.

Resolution of right-angled triangles.—Of the case in which the hypothenuse and a side nearly equal to it are given.

Knowing a side and two angles of any triangle, to find the other parts, and also the surface of the triangle.

Knowing two sides a and b of a triangle and the included angle C, to find the other parts and also the surface of the triangle.—The tang. $\frac{1}{2}(A-B)$ may be determined; or tang. A and tang. B directly.

Knowing the three sides a, b, c, to find the angles and the surface of the triangle.—Employment of the formula which gives tang. $\frac{1}{2}$ A.

Application to surveying for plans.

Measurement of bases with rods.

Measurement of angles.—Description and use of the circle.—Use of the telescope to render the line of sight more precise.—Division of the circle.—Verniers.

Measurement and calculation of a system of triangles.—Reduction of angles to the centres of stations.

How to connect the secondary points to the principal system.—Use of the plane table and of the compass.

2. SPHERICAL TRIGONOMETRY.

Fundamental relations ($\cos. a = \cos. b \cos. c + \sin. b \sin. c \cos. A$) between the sides and the angles of a spherical triangle.

To deduce thence the relations $\sin. A : \sin. B = \sin. a : \sin. b$; $\cot. a \sin. b - \cot. A \sin. C = \cos. b \cos. C$, and by the consideration of the supplementary triangle $\cos. A = -\cos. B \cos. C + \sin. B \sin. C \cos. a$.

Right-angled triangles.—Formulas $\cos. a = \cos. b \cos. c$; $\sin. b = \sin. a \sin. B$; $\tang. c = \tang. a \cos. B$, and $\tang. b = \sin. c \tang. B$.

In a right-angled triangle the three sides are less than 90°, or else two of the sides are greater than 90°, and the third is less. An angle and the side opposite to it are both less than 90°, or both greater.

Resolution of any triangles whatever:

1° Having given their three sides a, b, c, or their three angles A, B, C.—Formulas tang. $\frac{1}{2}a$, and tang. $\frac{1}{2}$ A, calculable by logarithms:

2° Having given two sides and the included angle, or two angles and the included side.—Formulas of Delambre:

3° Having given two sides and an angle opposite to one of them, or two angles and a side opposite to one of them. Employment of an auxiliary angle to render the formulas calculable by logarithms.

Applications.—Survey of a mountainous country.—Reduction of the base and of the angles to the horizon.—Determination of differences of level.

Knowing the latitude and the longitude of two points on the surface of the earth, to find the distance of those points.

V. ANALYTICAL GEOMETRY.

The important property of homogeneity must be given with clearness and simplicity.

The transformation of co-ordinates must receive some numerical applications, which are indispensable to make the student clearly see the meaning of the formulas.

The determination of tangents will be effected in the most general manner by means of the derivatives of the various functions, which we inserted in the programme of algebra. After having shown that this determination depends on the calculation of the derivative of the ordinate with respect to the abscissa, this will be used to simplify the investigation of the tangent to curves of the second degree and to curves whose equations contain transcendental functions. The discussion of these, formerly pursued by laborious indirect methods, will now become easy; and as curves with transcendental equations are frequently encountered, it will be well to exercise students in their discussion.

The properties of foci and of the directrices of curves of the second degree will be established directly, for each of the three curves, by means of the simplest equations of these curves, and without any consideration of the analytical properties of foci, with respect to the general equation of the second degree. With even greater reason will we dispense with examining whether curves of higher degree have foci, a question whose meaning even is not well defined.

We retained in algebra the elimination between two equations of the second degree with two unknown quantities, a problem which corresponds to the purely analytical investigation of the co-ordinates of the points of intersection of two curves of the second degree. The final equation is in general of the fourth degree, but we may sometimes dispense with calculating that equation. A graphical construction of the curves, carefully made, will in fact be sufficient to make known, approximately, the co-ordinates of each of the points of intersection; and when we shall have thus obtained an approximate solution, we will often be able to give it all the numerical rigor desirable, by successive approximations, deduced from the equations. These considerations will be extended to the investigation of the real roots of equations of any form whatever with one unknown quantity.

Analytical geometry of three dimensions was formerly entirely taught within the Polytechnic school, none of it being reserved for the course of admission. For some years past, however, candidates were required to know the equations of the right line in space, the equation of the plane, the solution of the problems which relate to it and the transfor-

mation of co-ordinates. But the consideration of surfaces of the second order was reserved for the interior teaching. We think it well to place this also among the studies to be mastered before admission, in accordance with the general principle now sought to be realized, of classing with them that double instruction which does not exact a previous knowledge of the differential calculus.

We have not, however, inserted here all the properties of surfaces of the second order, but have retained only those which it is indispensable to know and to retain. The transformation of rectilinear co-ordinates, for example, must be executed with simplicity, and the teacher must restrict himself to giving his pupils a succinct explanation of the course to be pursued; this will suffice to them for the very rare cases in which they may happen to have need of them. No questions will be asked relating to the general considerations, which require very complicated theoretical discussions, and especially that of the general reduction of the equation of the second degree with three variables. We have omitted from the problems relating to the right line and to the plane, the determination of the shortest distance of two right lines.

The properties of surfaces of the second order will be deduced from the equations of those surfaces, taken directly in the simplest forms. Among these properties, we place in the first rank, for their valuable applications, those of the surfaces which can be generated by the movement of a right line.

PROGRAMME OF ANALYTICAL GEOMETRY.

1. GEOMETRY OF TWO DIMENSIONS.

Rectilinear co-ordinates.—Position of a point on a plane.

Representation of geometric loci by equations.

Homogeneity of equations and of formulas.—Construction of algebraic expressions.

Transformation of rectilinear co-ordinates.

Construction of equations of the first degree.—Problems on the right line.

Construction of equations of the second degree.—Division of the curves which they represent into three classes.—Reduction of the equation to its simplest form by the change of co-ordinates.*

Problem of tangents.—The coefficient of inclination of the tangent to the curve, to the axis of the abscissas, is equal to the derivative of the ordinate with respect to the abscissa.

Of the ellipse.

Centre and axes.—The squares of the ordinates perpendicular to one of the axes are to each other as the products of the corresponding segments formed on that axis.

The ordinates perpendicular to the major axis are to the corresponding ordinates of the circle described on that axis as a diameter, in the constant ratio of the minor axis to the major.—Construction of the curve by points, by means of this property.

Foci; eccentricity of the ellipse.—The sum of the radii vectors drawn to any point of the ellipse is constant and equal to the major axis.—Description of the ellipse by means of this property.

* The students will apply these reductions to a numerical equation of the second degree, and will determine the situation of the new axes with respect to the original axes, by means of trigonometrical tables. They will show to the examiner the complete calculations of this reduction and the trace of the two systems of axes and of the curves.

Directrices.—The distance from each point of the ellipse to one of the foci, and to the directrix adjacent to that focus, are to each other as the eccentricity is to the major axis.

Equations of the tangent and of the normal at any point of the ellipse.*—The point in which the tangent meets one of the axes prolonged is independent of the length of the other axis.—Construction of the tangent at any point of the ellipse by means of this property.

The radii vectores, drawn from the foci to any point of the ellipse, make equal angles with the tangent at that point or the same side of it.—The normal bisects the angle made by the radii vectores with each other.—This property may serve to draw a tangent to the ellipse through a point on the curve, or through a point exterior to it.

The diameters of the ellipse are right lines passing through the centre of the curve.—The chords which a diameter bisects are parallel to the tangent drawn through the extremity of that diameter.—Supplementary chords. By means of them a tangent to the ellipse can be drawn through a given point on that curve or parallel to a given right line.

Conjugate diameters.—Two conjugate diameters are always parallel to supplementary chords, and reciprocally.—Limit of the angle of two conjugate diameters.—An ellipse always contains two equal conjugate diameters.—The sum of the squares of two conjugate diameters is constant.—The area of the parallelogram constructed on two conjugate diameters is constant.—To construct an ellipse, knowing two conjugate diameters and the angle which they make with each other.

Expression of the area of an ellipse in function of its axes.

Of the hyperbola.

Centre and axes.—Ratio of the squares of the ordinates perpendicular to the transverse axes.

Of foci and of directrices; of the tangent and of the normal; of diameters and of supplementary chords.—Properties of these points and of these lines, analogous to those which they possess in the ellipse.

Asymptotes of the hyperbola.—The asymptotes coincide with the diagonals of the parallelogram formed on any two conjugate diameters.—The portions of a secant comprised between the hyperbola and its asymptotes are equal.—Application to the tangent and to its construction.

The rectangle of the parts of a secant, comprised between a point of the curve and the asymptotes, is equal to the square of half of the diameter to which the secant is parallel.

Form of the equation of the hyperbola referred to its asymptotes.

Of the parabola.

Axis of the parabola.—Ratio of the squares of the ordinates perpendicular to the axis.

Focus and directrix of the parabola.—Every point of the curve is equally distant from the focus and from the directrix.—Construction of the parabola.

The parabola may be considered as an ellipse, in which the major axis is indefinitely increased while the distance from one focus to the adjacent summit remains constant.

Equations of the tangent and of the normal.—Sub-tangent and sub-normal. They furnish means of drawing a tangent at any point of the curve.

The tangent makes equal angles with the axis and with the radius vector drawn to the point of contact.—To draw, by means of this property, a tangent to the parabola, 1° through a point on the curve; 2° through an exterior point.

All the diameters of the parabola are right lines parallel to the axis, and reciprocally.—The chords which a diameter bisects are parallel to the tangent drawn at the extremity of that diameter.

Expression of the area of a parabolic segment.

Polar co-ordinates.—To pass from a system of rectilinear and rectangular co-ordinates to a system of polar co-ordinates, and reciprocally.

Polar equations of the three curves of the second order, the pole being situated at a focus, and the angles being reckoned from the axis which passes through that focus.

Summary discussion of some transcendental curves.—Determination of the tangent at one of their points.

Construction of the real roots of equations of any form with one unknown quantity.—Investigation of the intersections of two curves of the second degree.—Numerical applications of these formulas.

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* They will be deduced from the property, previously demonstrated, of the derivative of the ordinate with respect to the abscissa.

2. GEOMETRY OF THREE DIMENSIONS.

The sum of the projections of several consecutive right lines upon an axis is equal to the projection of the resulting line.—The sum of the projections of a right line on three rectangular axes is equal to the square of the right line.—The sum of the squares of the cosines of the angles which a right line makes with three rectangular right lines is equal to unity.

The projection of a plane area on a plane is equal to the product of that area by the cosine of the angle of the two planes.

Representation of a point by its co-ordinates.—Equations of lines and of surfaces.

Transformation of rectilinear co-ordinates.

Of the right line and of the plane.

Equations of the right line.—Equation of the plane.

To find the equations of a right line, 1° which passes through two given points, 2° which passes through a given point and which is parallel to a given line.

To determine the point of intersection of two right lines whose equations are known.

To pass a plane, 1° through three given points; 2° through a given point and parallel to a given plane; 3° through a point and through a given right line.

Knowing the equations of two planes, to find the projections of their intersection.

To find the intersection of a right line and of a plane, their equations being known.

Knowing the co-ordinates of two points, to find their distance.

From a given point to let fall a perpendicular on a plane; to find the foot and the length of that perpendicular (rectangular co-ordinates).

Through a given point to pass a plane perpendicular to a given right line (rectangular co-ordinates).

Through a given point, to pass a perpendicular to a given right line; to determine the foot and the length of that perpendicular (rectangular co-ordinates).

Knowing the equations of a right line, to determine the angles which that line makes with the axes of the co-ordinates (rectangular co-ordinates).

To find the angle of two right lines whose equations are known (rectangular co-ordinates).

Knowing the equation of a plane, to find the angles which it makes with the co-ordinate planes (rectangular co-ordinates).

To determine the angle of two planes (rectangular co-ordinates).

To find the angle of a right line and of a plane (rectangular co-ordinates).

Surfaces of the second degree.

They are divided into two classes; one class having a centre, the other not having any. Co-ordinates of the centre.

Of diametric planes.

Simplification of the general equation of the second degree by the transformation of co-ordinates.

The simplest equations of the ellipsoid, of the hyperboloid of one sheet and of two sheets, of the elliptical and the hyperbolic paraboloid, of cones and of cylinders of the second order.

Nature of the plane sections of surfaces of the second order.—Plane sections of the cone, and of the right cylinder with circular base.—Anti-parallel section of the oblique cone with circular base.

Cone asymptote to an hyperboloid.

Right-lined sections of the hyperboloid of one sheet.—Through each point of a hyperboloid of one sheet two right lines can be drawn, whence result two systems of right-lined generatrices of the hyperboloid.—Two right lines taken in the same system do not meet, and two right lines of different systems always meet.—All the right lines situated on the hyperboloid being transported to the centre, remaining parallel to themselves, coincide with the surface of the asymptote cone.—Three right lines of the same system are never parallel to the same plane.—The hyperboloid of one sheet may be generated by a right line which moves along three fixed right lines, not parallel to the same plane; and, reciprocally, when a right line slides on three fixed lines, not parallel to the same plane, it generates a hyperboloid of one sheet.

Right-lined sections of the hyperbolic paraboloid.—Through each point of the surface of the hyperbolic paraboloid two right lines may be traced, whence results the generation of the paraboloid by two systems of right lines.—Two right lines of the same system do not meet, but two right lines of different systems always meet.—All the right lines of the same system are parallel to the same plane.—The hyperbolic paraboloid may be generated by the movement of a right line which slides on three fixed right lines which are parallel to the same plane; or by a right line which slides on two fixed right lines, itself remaining always parallel to a given plane. Reciprocally, every surface resulting from one of these two modes of generation is a hyperbolic paraboloid.

General equations of conical surfaces and of cylindrical surfaces.

VI. DESCRIPTIVE GEOMETRY.

The general methods of Descriptive Geometry,—their uses in Stone-cutting and Carpentry, in Linear Perspective, and in the determination of the Shadows of bodies,—constitute one of the most fruitful branches of the applications of mathematics. The course has always been given at the Polytechnic School with particular care, according to the plans traced by the illustrious *Monge*, but no part of the subject has heretofore been required for admission. The time given to it in the school, being however complained of on all sides as insufficient for its great extent and important applications, the general methods of Descriptive Geometry will henceforth be retrenched from the internal course, and be required of all candidates for admission.

As to the programme itself, it is needless to say any thing, for it was established by *Monge*, and the extent which he gave to it, as well as the methods which he had created, have thus far been maintained. We merely suppress the construction of the shortest distance between two right lines, which presents a disagreeable and useless complication.

Candidates will have to present to the examiner a collection of their graphical constructions (*épures*) of all the questions of the programme, signed by their teacher. They are farther required to make free-hand sketches of five of their *épures*.

PROGRAMME OF DESCRIPTIVE GEOMETRY.

*Problems relating to the point, to the straight line, and to the plane.**

Through a point given in space, to pass a right line parallel to a given right line, and to find the length of a part of that right line.

Through a given point, to pass a plane parallel to a given plane.

To construct the plane which passes through three points given in space.

Two planes being given, to find the projections of their intersection.

A right line and a plane being given, to find the projections of the point in which the right line meets the plane.

Through a given point, to pass a perpendicular to a given plane, and to construct the projections of the point of meeting of the right line and of the plane.

Through a given point, to pass a right line perpendicular to a given right line, and to construct the projections of the point of meeting of the two right lines.

A plane being given, to find the angles which it forms with the planes of projection.

Two planes being given, to construct the angle which they form between them.

Two right lines which cut each other being given, to construct the angle which they form between them.

To construct the angle formed by a right line and by a plane given in position in space.

Problems relating to tangent planes.

To draw a plane tangent to a cylindrical surface or to a conical surface, 1° through a point taken on the surface; 2° through a point taken out of the surface; 3° parallel to a given right line.

Through a point taken on a surface of revolution, whose meridian is known, to pass a plane tangent to that surface.

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* The method of the change of the planes of projection will be used for the resolution of these problems.

Problems relating to the intersection of surfaces.

To construct the section made, on the surface of a right and vertical cylinder, by a plane perpendicular to one of the planes of projection.—To draw the tangent to the curve of intersection.—To make the development of the cylindrical surface, and to refer to it the curve of intersection, and also the tangent.

To construct the intersection of a right cone by a plane perpendicular to one of the planes of projection. Development and tangent.

To construct the right section of an oblique cylinder.—To draw the tangent to the curve of intersection. To make the development of the cylindrical surface, and to refer to it the curve which served as its base, and also its tangents.

To construct the intersection of a surface of revolution by a plane, and the tangents to the curve of intersection.—To resolve this question, when the generating line is a right line which does not meet the axis.

To construct the intersection of two cylindrical surfaces, and the tangents to that curve.

To construct the intersection of two oblique cones, and the tangents to that curve.

To construct the intersection of two surfaces of revolution whose axes meet.

VII. OTHER REQUIREMENTS.

The preceding six heads complete the outline of the elementary course of mathematical instruction which it was the object of this article to present; but a few more lines may well be given to a mere enumeration of the other requirements for admission to the school.

MECHANICS comes next. The programme is arranged under these heads: Simple motion and compound motion; Inertia; Forces applied to a free material point; Work of forces applied to a movable point; Forces applied to a solid body; Machines.

PHYSICS comprises these topics: General properties of bodies; Hydrostatics and hydraulics; Densities of solids and liquids; Properties of gases; Heat; Steam; Electricity; Magnetism; Acoustics; Light.

CHEMISTRY treats of Oxygen; Hydrogen; Combinations of hydrogen with oxygen; Azote or nitrogen; Combinations of azote with oxygen; Combination of azote with hydrogen, or ammonia; Sulphur; Chlorine; Phosphorus; Carbon.

COSMOGRAPHY describes the Stars; the Earth; the Sun; the Moon; the Planets; Comets; the Tides.

HISTORY and GEOGRAPHY treat of Europe from the Roman Empire to the accession of Louis XVI.

GERMAN must be known sufficiently for it to be translated, spoken a little, and written in its own characters.

DRAWING, besides the *épures* of descriptive geometry, must have been acquired sufficiently for copying an academic study, and shading in pencil and in India ink.

Will not our readers agree with M. Coriolis, that "*There are very few learned mathematicians who could answer perfectly well at an examination for admission to the Polytechnic School*"?

SCHOOLS OF PREPARATION FOR THE POLYTECHNIC SCHOOL.

THERE are strictly speaking no Junior Military Schools preparatory to the Polytechnic School, or to the Special Military School at St. Cyr. These schools are recruited in general from the *Lycées* and other schools for secondary instruction, upon which they exert a most powerful influence. Until 1852 there was no special provision made in the courses of instruction in the *Lycées* for the mathematical preparation required for admission into the Polytechnic, and the Bachelor's degree in science could not be obtained without being able to meet the requirements in Latin, rhetoric, and logic for graduation in the arts, which was necessary to the profession of law, medicine, and theology. In consequence, young men who prepared to be candidates for the preliminary examinations at the Polytechnic and the St. Cyr, left the *Lycées* before graduation in order to acquire more geometry and less literature in the private schools, or under private tuition.

A new arrangement, popularly called the *Bifurcation*, was introduced by the Decrees of the 10th of April, 1852; and has now come into operation. The conditions demanded for the degree in science were adapted to the requirements of the Military Schools; and in return for this concession it is henceforth to be exacted from candidates for the Military Schools. The diploma of arts is no longer required before the diploma of science can be given. The instruction, which in the upper classes of the *Lycées* had hitherto been mainly preparatory for the former, takes henceforth at a certain point (called that of *Bifurcation*) two different routes, conducting separately, the one to the baccalaureate of arts, the other to that of science. The whole system of teaching has accordingly been altered. Boys wanting to study algebra are no longer carried through a long course of Latin; mathematics are raised to an equality with literature; and thus military pupils—pupils desirous of admission at the Polytechnic and St. Cyr, may henceforth, it is hoped, obtain in the *Lycées* all the preparation which they had latterly sought elsewhere.

Under this new system the usual course for a boy seems to be the following:—

He enters the *Lycée*, in the Elementary Classes; or, a little later, in the Grammar Classes, where he learns Latin and begins Greek. At the age of about fourteen, he is called upon to pass an examination for admission into the Upper Division, and here, in accordance with the new regulations, he makes his choice for mathematics or for literature, the studies henceforth being divided, one course leading to the bachelorship of science, the other to that of arts.

In either case he has before him three yearly courses, three classes—the Third, the Second, and what is called the Rhetoric. At the close of this, or after passing, if he pleases, another year in what is called the Logic, he may go up for his bachelor's degree. The boy who wants to go to St. Cyr or the Polytechnic chooses, of course, the mathematical division leading to the diploma he will want, that of a bachelor of *science*. He accordingly begins algebra, goes on to trigonometry, to conic sections, and to mechanics, and through corresponding stages in natural philosophy, and the like. If he chooses to spend a fourth year in the Logic, he will be chiefly employed in going over his subjects again. He may take his bachelor's degree at any time after finishing his third year; and he may, if he pleases, having taken that, remain during a fifth or even a sixth year, in the class of Special Mathematics.

If he be intended for St. Cyr, he may very well leave at the end of his year in Rhetoric, taking of course his degree. One year in the course of Special Mathematics will be required before he can have a chance for the Polytechnic. Usually the number of students admitted at the latter, who have not passed more than one year in the *mathematiques spéciales* is very small. Very probably the young aspirant would try at the end of his first year in this class, and would learn by practice to do better at the end of the second.

The following are the studies of the mathematical section of the upper division as laid down by the ordinance of 30th August, 1854.

THE THIRD CLASS (*Troisième*,) at fourteen years old.

Arithmetic and first notions of Algebra. Plane Geometry and its applications. First notions of Chemistry and Physics. General notions of Natural History; Principles of classification. Linear and imitative Drawing.

THE SECOND CLASS (*Seconde*,) at fifteen years old.

Algebra; Geometry, figures in space, recapitulation; Applications of Geometry, notions of the geometrical representations of bodies by projections; Rectilineal Trigonometry; Chemistry; Physics; and Drawing.

THE RHETORIC, at sixteen years old.

Exercises in Arithmetic and Algebra; Geometry; notions on some common curves; and general recapitulation; Applications of Geometry; notions of leveling and its processes; recapitulation of Trigonometry; Cosmography; Mechanics; Chemistry concluded and reviewed; Zoölogy and Animal Physiology; Botany and Vegetable Physiology; Geology; Drawing. (The pupil may now be ready for the Degree and for St. Cyr.)

THE LOGIC, at seventeen years old.

Six lessons a week are employed in preparation for the bachelorship of science, and in a methodical recapitulation of the courses of the three preceding years according to the state of the pupil's knowledge.

Two lessons a week are allowed for reviewing the literary instruction; evening lessons in Latin, French, English, and German, and in History and Geography, having been given through the whole previous time.

THE SPECIAL MATHEMATICS, at eighteen and nineteen years old.

Five lessons a week are devoted to these studies; in the other lessons the pupils join those of the Logic class for reviewing all their previous subjects, whether for the bachelorship in science or for competition for admission at the *Ecole Normale* or the Polytechnic.

It will only be necessary to add a few sentences in explanation of the methods pursued in the upper classes of the *Lycées*. The classes are large—from 80 to above 100; the lessons strictly professorial lectures, with occasional questions, as at the Polytechnic itself. In large establishments the class is divided, and two professors are employed, giving two parallel courses on the same subject. To correct and fortify this general teaching, we find, corresponding to the interrogations of the Polytechnic, what are here called conferences. The members of the large class are examined first of all in small detachments of five or six by their own professors once a week; and, secondly, a matter of yet greater importance, by the professor who is conducting the parallel course, and by professors who are engaged for this purpose from other *Lycées* and preparatory schools, and from among the *répétiteurs* of the Polytechnic and the Ecole Normale themselves. It appeared by the table of the examinations of this latter kind which had been passed by the pupils of the class of Special Mathematics at the *Lycée* St. Louis, that the first pupil on the list had in the interval between the opening of the school and the date of our visit (February 16th) gone through as many as twenty-four.

The assistants, who bear the name of *répétiteurs* at the *Lycées*, do not correspond in any sense to those whom we shall hereafter notice at the Ecole Polytechnique. They are in the *Lycées* mere superintendents in the *salles d'étude*, who attend to order and discipline, who give some slight occasional help to the pupils, and may be em-

ployed in certain cases, where the parents wish for it, in giving private tuition to the less proficient. The system of *salles d'étude* appears to prevail universally; the number of the pupils placed in each probably varying greatly. At the Polytechnic we found eight or ten pupils in each; at St. Cyr as many as 200. The number considered most desirable at the *Lycée* of St. Louis was stated to be thirty.

It thus appears that in France not only do private establishments succeed in giving preparation for the military schools, but that even in the first-class public schools, which educate for the learned professions, it has been considered possible to conduct a series of military or science classes by the side of the usual literary or arts classes. The common upper schools are not, as they used to be, and as with us they are, *Grammar* schools, they are also *Science* schools. In every *Lycée* there is, so to say, a sort of elementary polytechnic department, giving a kind of instruction which will be useful to the future soldier, and at the same time to others, to those who may have to do with mines, manufactures, or any description of civil engineering. There is thus no occasion for Junior Military Schools in France, for all the schools of this class are more or less of a military character in their studies.

The conditions of admission to the examination for the degree of Bachelor of Science are simply, sixteen years of age, and the payment of fees amounting to about 200 fr. (10*l.*) Examinations are held three times a year by the Faculties at Paris, Besançon, Bordeaux, Caen, Clermont, Dijon, Grenoble, Lille, Lyons, Marseilles, Montpellier, Nancy, Poitiers, Rennes, Strasburg, and Toulouse, and once a year at Ajaccio, Algiers, and nineteen other towns. There is a written examination of six hours, and a vivâ voce examination of an hour and a quarter. It is, of course, only a *pass* examination, and is said to be much less difficult than the competitive examination for admission to St. Cyr.—*Report of English Commissioners*, 1856.

THE POLYTECHNIC SCHOOL OF FRANCE.

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THE POLYTECHNIC SCHOOL AT PARIS.*

I. FOUNDATION AND HISTORY.

THE origin of the *Ecole Polytechnique* dates from a period of disorder and distress in the history of France which might seem alien to all intellectual pursuits, if we did not remember that the general stimulus of a revolutionary period often acts powerfully upon thought and education. It is, perhaps, even more than the Institute, the chief scientic creation of the first French Revolution. It was during the government of the committee of public safety, when Carnot, as war minister, was gradually driving back the invading armies, and reorganizing victory out of defeat and confusion, that the first steps were taken for its establishment. A law, dating the 1st Ventose, year II., the 12th of March 1794, created a "Commission des Travaux Publics," charged with the duty of establishing a regular system for carrying on public works; and this commission ultimately founded a central school for public works, and drew up a plan for the competitive examination of candidates for admission to the service. It was intended at first to give a complete education for some of the public services, but it was soon changed into a preparatory school, to be succeeded by special schools of application. This was the Ecole Polytechnique.

The school and its plan were both owing to an immediate and pressing want. It was to be partly military and partly civil. Military, as well as civil education had been destroyed by the revolutionists. The committee of public safety had, indeed, formed a provisional school for engineers at Metz, to supply the immediate wants of the army on the frontier, and at this school young men were hastily taught the elements of fortification, and were sent direct to the troops, to learn as they best could, the practice of their art. "But such a method," says the report accompanying the law which founded the school, "does not form engineers *in any true sense of the term*, and can only be justified by the emergency of the

* Compiled from "*Report and Appendix of English Commissioners on Military Education.*" 1857.

time. The young men should be recalled to the new school to complete their studies." Indeed no one knew better than Carnot, to use the language of the report, "that patriotism and courage can not "always supply the want of knowledge;" and in the critical campaigns of 1793—4, he must often have felt the need of the institution which he was then contributing to set on foot. Such was the immediate motive for the creation of this school. At first, it only included the engineers amongst its pupils. But the artillery were added within a year.

We must not, however, omit to notice its civil character, the combination of which with its military object forms its peculiar feature, and has greatly contributed to its reputation. Amongst its founders were men, who though ardent revolutionists, were thirsting for the restoration of schools and learning, which for a time had been totally extinguished. The chief of these, besides Carnot, were Monge and Fourcroy, Berthollet and Lagrange. Of Carnot and Lagrange, one amongst the first of war ministers, the other one of the greatest of mathematicians, we need not say more. Berthollet, a man of science and practical skill, first suggested the school; Monge, the founder of Descriptive Geometry, a favorite *savant* of Napoleon though a zealous republican, united to real genius that passion for teaching and for his pupils, which makes the *beau idéal* of the founder of a school; and Fourcroy was a man of equal practical tact and science, who at the time had great influence with the convention, and was afterwards intrusted by Napoleon with much of the reorganization of education in France.

When the school first started there was scarcely another of any description in the country. For nearly three years the revolution had destroyed every kind of teaching. The attack upon the old schools, in France, as elsewhere, chiefly in the hands of the clergy, had been begun by a famous report of Talleyrand's, presented to the legislative assembly in 1791, which recommended to suppress all the existing academies within Paris and the provinces, and to replace them by an entirely new system of national education through the country. In this plan a considerable number of military schools were proposed, where boys were to be educated from a very early age. When the violent revolutionists were in power, they adopted the destructive part of Talleyrand's suggestions without the other. All schools, from the university downwards, were destroyed; the large exhibitions or *Bourses*, numbering nearly 40,000, were confiscated or plundered by individuals, and even the military schools and those for the public works (which were abso-

lutely necessary for the very roads and the defense of the country) were suppressed or disorganized. The school of engineers at Mézières (an excellent one, where Monge had been a professor,) and that of the artillery at La Fère, were both broken up, whilst the murder of Lavoisier, and the well known saying in respect to it, that "the Republic had no need of chemists," gave currency to a belief, which Fourcroy expressed in proposing the Polytechnic, "that the late conspirators had formed a deliberate plan to destroy the arts and sciences, and to establish their tyranny on the ruins of human reason."

Thus it was on the ruin of all the old teaching, that the new institution was erected; a truly *revolutionary* school, as its founders delighted to call it, using the term as it was then commonly used, as a synonym for all that was excellent. And then for the first time avowing the principle of public competition, its founders, Monge and Fourcroy, began their work with an energy and enthusiasm which they seem to have left as a traditional inheritance to their school. It is curious to see the difficulties which the bankruptcy of the country threw in their way, and the vigor with which, assisted by the summary powers of the republican government, they overcame them. They begged the old Palais Bourbon for their building; were supplied with pictures from the Louvre; the fortunate capture of an English ship gave them some uncut diamonds for their first experiments; presents of military instruments were sent from the arsenals of Havre; and even the hospitals contributed some chemical substances In fine, having set their school in motion, the government and its professors worked at it with such zeal and effect, that within five months after their project was announced, they had held their first entrance examination, open to the competition of all France, and started with three hundred and seventy-nine pupils.

The account of one of these first pupils, who is among the most distinguished still surviving ornaments of the Polytechnic, will convey a far better idea of the spirit of the young institution than could be given by a more lengthy description. M. Biot described to us vividly the zeal of the earliest teachers, and the thirst for knowledge which, repressed for awhile by the horrors of the period, burst forth with fresh ardor amongst the French youth of the time. Many of them, he said, like himself, had been carried away by the enthusiasm of the revolution, and had entered the army. "My father had sent me," he added, "to a mercantile house, and indeed I never felt any great vocation to be a soldier, but *Que voulez vous?*

les Prussiens etaient en Champagne." He joined the army, served two years under Dumouriez, and returned to Paris in the reign of terror, "to see from his lodgings in the Rue St. Honore the very generals who had led us to victory, Custine and Biron, carried by in the carts to the guillotine. "Imagine what it was when we heard that Robespierre was dead, and that we might return safely to study after all this misery, and then to have for our teachers La Place, Lagrange, and Monge. We felt like men brought to life again after suffocation. Lagrange said, modestly, "Let me teach them arithmetic." Monge was more like our father than our teacher; he would come to us in the evening, and assist us in our work till midnight, and when he explained a difficulty to one of our *chefs de brigade*, it ran like an electric spark through the party." The pupils were not then, he told us, as they have since been, shut up in barracks, they were left free, but there was no idleness or dissipation amongst them. They were united in zealous work and in good *camaraderie*, and any one known as a bad character was avoided. This account may be a little tinged by enthusiastic recollections, but it agreed almost entirely with that of M. de Barante, who bore similar testimony to the early devotion of the pupils, and the unique excellence of the teaching of Monge.

We are not, however, writing a history of this school, and must confine ourselves to such points as directly illustrate its system of teaching and its organization. These may be roughly enumerated in the following order:

1. Its early history is completed by the law of its organization, given it by La Place in his short ministry of the interior. This occurred in the last month of 1799, a memorable era in French history, for it was immediately after the revolution of the 18th of Brumaire, when Napoleon overthrew the Directory and made himself First Consul. One of his earliest acts was to sign the charter of his great civil and military school. This charter or decree deserves some attention, because it is always referred to as the law of the foundation of the school. It determined the composition of the two councils of instruction and improvement, the bodies to which the direction of the school was to be, and still is, intrusted; some of its marked peculiarities in the mode and subject of teaching. It is important to notice each of the two points.

The direction of the school was at first almost entirely in the hands of its professors, who formed what is still called its Council of Instruction. Each of them presided over the school alternately for one month, a plan copied from the revolutionary government of

the Convention. In the course of a few years, however, another body was added, which has now the real management of the school. This is called the "Council of Improvement" (*Conseil de perfectionnement,*) and a part of its business is to see that the studies form a good preparation for those of the more special schools (*écoles d'application*) for the civil and military service. It consists of eminent men belonging to the various public departments supplied by the school, and some of the professors. It has had, as far as we could judge, an useful influence; *first*, as a body not liable to be prejudiced in its proposals by the feelings of the school, and yet interested in its welfare and understanding it; *secondly*, as having shown much skill in the difficult task of making the theoretical teaching of the Polytechnic a good introduction to the practical studies of the public service; *thirdly*, as being sufficiently influential, from the character of its members, to shield the school from occasional ill-judged interference. It should be added that hardly any year has passed without the Council making a full report on the studies of the school, with particular reference to their bearing on the Special Schools of Application.

The method of scientific teaching has been peculiar from the beginning. It is the most energetic form of what may be called the *repetitorial* system, a method of teaching almost peculiar to France, and which may be described as a very able combination of professional and tutorial teaching. The object of the *répétiteur*, or private tutor, is to second every lecture of the professor, to explain and fix it by ocular demonstration, explanations, or examination. This was a peculiarity in the scheme of Monge and Fourcroy. The latter said, in the first programme, "Our pupils must not only learn, they must at once carry out their theory. We must distribute them into small rooms, where they shall practice the plans of descriptive geometry, which the professors have just shown them in their public lectures. And in the same manner they must go over in practice (*répéteront*) in separate laboratories the principal operations of chemistry." To carry out this system the twenty best pupils, of whom M. Biot was one, were selected as *répétiteurs* soon after the school had started. Since then the vacancies have always been filled by young but competent men, aspiring themselves to become in turn professors. They form a class of teachers more like the highest style of private tutors in our universities, or what are called in Germany *Privat-docenten*, than any other body—with this difference, that they do not give their own lectures, but breaking up the professor's large class into small classes of five and six pupils, exam-

ine these in *his* lecture. The success of this attempt we shall de scribe hereafter.

2. A change may be noticed which was effected very early by the Council of Improvement—the union of pupils for artillery and engineers in a single school of application. The first report in December 1800, speaks of the identity in extent and character of the studies required for these two services; and in conformity with its recommendation, the law of the 3rd of October 1802, (12th Vendémiaire, XI.) dissolved the separate artillery school at Châlons, and established the united school for both arms in the form which it still retains at Metz.

3. In 1805 a curious change was made, and one very characteristic of the school. The pupils have always been somewhat turbulent, and generally on the side of opposition. In the earliest times they were constantly charged with *incivisme*, and the aristocracy was said to have "taken refuge within its walls." In fact, one of its earliest and of its few great *literary* pupils, M. de Barante, confirmed this statement, adding, as a reason, that the school gave for a while the only good instruction in France. It was in consequence of some of these changes that the pupils who had hitherto lived in their own private houses or lodgings in Paris, were collected in the school building. This "*casernement*," said to be immediately owing to a burst of anger of Napoleon, naturally tended to give the school a more military character; but it was regarded as an unfortunate change by its chief scientific friends. "*Ah! ma pauvre école!*" M. Biot told us he had exclaimed, when he saw their knapsacks on their beds. He felt, he said, that the enthusiasm of free study was gone, and that now they would chiefly work by routine and compulsion.

4. The year 1809 may be called the epoch at which the school attained its final character. By this time the functions, both of boards and teachers, were accurately fixed, some alterations in the studies had taken place, and the plan of a final examination had been drawn up, according to which the pupils were to obtain their choice of the branch of the public service they preferred. In fact, the school may be said to have preserved ever since the form it then assumed, under a variety of governments and through various revolutions, in most of which, indeed, its pupils have borne some share; and one of which, the restoration of 1816, was attended with its temporary dissolution.

Thus, during the first years after its foundation the Polytechnic grew and flourished in the general dearth of public teaching, being

indeed not merely the only great school, but, until the Institute was founded, the only scientific body in France. Working on its first idea of high professorial lectures, practically applied and explained by *répétiteurs*, its success in its own purely scientific line was, and has continued to be, astonishing. Out of its sixteen earliest professors, ten still retain an European name. Lagrange, Monge, Fourcroy, La Place, Guyton de Morveau were connected with it. Malus, Hauy, Biot, Poisson, and De Barante, were among its earliest pupils. Arago, Cauchy, Cavaignac, Lamoricière, with many more modern names, came later. All the great engineers and artillerymen of the empire belonged to it, and the long pages in its calendar of distinguished men are the measure of its influence on the civil and military services of France. In fact its pupils, at a time of enormous demands, supplied all the scientific offices of the army, and directed all the chief public works, fortresses, arsenals, the improvement of cities, the great lines of roads, shipbuilding, mining—carried out, in a word, most of the great improvements of Napoleon. He knew the value of his school, "the hen" as he called it, "that laid him golden eggs"—and perhaps its young pupils were not improved by the excessive official patronage bestowed by him upon "the envy of Europe," "the first school in the world." It can not, however, be matter of surprise, that its vigor and success should have caused Frenchmen, even those who criticise its influence severely, to regard it with pride as an institution unrivaled for scientific purposes.

It is not necessary to give any detailed account of the later history of the school, but we must remark that disputes have frequently arisen with regard to the best mode of harmonizing its teaching with that of the special schools of application to which it conducts. These disputes have been no doubt increased by the union of a civil and military object in the same school. The scientific teaching desirable for some of the higher civil professions has appeared of doubtful advantage to those destined for the more practical work of war. There has been always a desire on the one side to qualify pure mathematics by application, a strong feeling on the other that mathematical study sharpens the mind most keenly for some of the practical pursuits of after life. We should add, perhaps, that there has been some protest in France (though little heard among the scientific men who have been the chief directors of the school) against the *esprit faux*, the exclusive pursuit of mathematics to the utter neglect of literature, and the indifference to moral and historical studies. Some one or other of these com-

plaints any one who studies the *literature*, the pamphlets, and history of the school will find often reproduced in the letters of war ministers, of artillery and engineer officers commanding the school of application at Metz, or of committees from the similar schools for the mines and the roads and bridges. The last of these occasions illustrates the present position of the school.

On the 5th of June 1850, the legislative assembly appointed a mixed commission of military men and civilians, who were charged to revise all the programs of instruction, and to recommend all needful changes in the studies of the pupils, both those preparatory to entrance* and those actually pursued in the school. The commission was composed as follows :—

M. Thenard, Member of the Academy of Sciences, and of the Board of Improvement of the Polytechnic School, President.
Le Verrier, Member of the Academy of Sciences and of the Legislative Assembly, Reporter.
Noizet, General of Brigade of Engineers.
Poncelet, General of Brigade of Engineers, Commandant of the Polytechnic School, Member of the Academy of Sciences.
Piobert, General of Brigade of Artillery, Member of the Academy of Sciences.
Mathieu, Rear Admiral.
Duhamel, Member of the Academy of Sciences, Director of Studies at the Polytechnic School.
Mary, Divisional Inspector of Roads and Bridges.
Morin, Colonel of Artillery, Member of the Academy of Sciences.
Regnault, Engineer of Mines, Member of the Academy of Sciences.
Olivier, Professor at the *Conservatoire des Arts et Metiers.*
Debacq, Secretary for Military Schools at the Ministry of War, Secretary.

A chronic dispute which has gone on from the very first year of the school's existence, between the exclusive study of abstract mathematics on the one hand, and their early practical application on the other, was brought to a head (though it has scarcely been set at rest) by this commission. All the alterations effected have been in the direction of eliminating a portion of the pure mathematics, and of reducing abstract study to the limits within which it was believed to be most directly applicable to practice. The results, however, are still a subject of vehement dispute, in which most of the old scientific pupils of the Polytechnic, and many of what may be styled its most practical members, the officers of the artillery and engineers, are ranged on the side of "early and deep scientific study *versus* early practical applications." It is, indeed, a question which touches the military pupils nearly, since it is in their case particularly that the proposed abstract studies of the Polytechnic might be thought of the most doubtful advantage. We do not try to solve the problem here, though the facts elsewhere stated will afford some materials for judgment. We incline to the opin-

* In an Analysis of the Report of this Commission, see page 97.

ion of those who think that the ancient *genius loci*, the traditional teaching of the school, will be too strong for legislative interference, and that, in spite of recent enactments, abstract science and analysis will reign in the lecture-rooms and halls of study of the Polytechnic, now as in the days of Monge.

II. AN OUTLINE OF THE MANAGEMENT AND OF THE ESTABLISHMENT OF THE SCHOOL, ETC.

The Polytechnic, as we have said, is a preparatory and general scientific school; its studies are not exclusively adapted for any one of the departments to which at the close of its course the scholars will find themselves assigned; and on quitting it they have, before entering on the actual discharge of their duties of whatever kind, to pass through a further term of teaching in some one of the schools of application specially devoted to particular professions.

The public services for which it thus gives a general preparation are the following:

Military: Under the Minister at War.

Artillery (*Artillerie de terre.*)
Engineers (*Génie.*)
The Staff Corps (*Corps d'Etat Major.*)
The Department of Powder and Saltpetre (*Poudres et Salpêtres.*)

Under the Minister of Marine.

Navy, (*Marine.*)
Marine Artillery (*Artillerie de mer.*)
Naval Architects (*Génie maritime.*)
The Hydrographical Department (*Corps des Ingénieurs Hydrographes.*)

Civil: Under the Minister of Public Works.

The Department of Roads and Bridges (*Ponts-et-chaussées.*)
The Department of Mines (*Mines.*)

Under the Minister of the Interior.

The Telegraph Department (*Lignes Télégraphiques.*)

Under the minister of Finance.

The Tobacco Department (*Administration des Tabacs.*)

To these may be added at any time, by a decree on the part of the government, any other departments, the duties of which appear to require an extensive knowledge of mathematics, physics, or chemistry.

Admission to the school is, and has been since its first commencement in 1794, obtained by competition in a general examination, held yearly, and open to all. Every French youth, between the age of sixteen and twenty, (or if in the army up to the age of twenty-five,) may offer himself as a candidate.

A board of examiners passes through France once every year, and examines all who present themselves, that have complied with the conditions, which are fully detailed in the decree given in the appendix. It commences at Paris.

A list of such of the candidates as are found eligible for admittance to the Polytechnic is drawn up from the proceedings of the board, and submitted to the minister at war; the number of places likely to be vacant has already been determined, and the minister fixes the number of admissions accordingly. The candidates admitted are invariably taken in the order of merit.

The annual charge for board and instruction is 40*l.* (1,000 fr.,) payable in advance in four installments. In addition there is the cost of outfit, varying from 20*l.* to 24*l.* Exhibitions, however, for the discharge of the whole or of one-half of the expense (*bourses* and *demi-bourses*,) are awarded by the state in favor of *all* the successful candidates, whose parents can prove themselves to be too poor to maintain their children in the school. Outfits and half outfits (*trousseaux*) and *demi-trousseaux*) are also granted in these cases, on the entrance of the student into the school; and the number of these *boursiers* and *demi-boursiers* amounts at the present time to one-third of the whole.

The course of study is completed in two years. On its successful termination which is preceded by a final examination, the students are distributed into the different services, the choice being offered them in the order of their merit, and laid down in the classified list drawn up after the examination. If it so happen that the number of places or the services which can be offered is not sufficient for the number of qualified students, those at the bottom of the list are offered service in the infantry or cavalry, and those who do not enter the public service, are supplied with certificates of having passed successfully through the school. Students who have been admitted into the school from the army, are abliged to re-enter the army.

All others, as has been said, have the right of choosing, according to their position on the list, the service which they prefer, so far, that is, as the number of vacancies in that service will allow; or they may if they please decline to enter the public service at all.

Such is a general outline of the plan and object of the school. We may add that, besides its military staff, it employs no less than thirty-nine professors and teachers; that it has four boards of management, and that ten scientific men unconnected with the school, and amongst the most distinguished in France, conduct its examina-

tions. The magnitude of this establishment for teaching may be estimated by the fact, that the number of pupils rarely exceeds three hundred and fifty, and is often much less.

A fuller enumeration of these bodies will complete our present sketch.

I. The military establishment consists of:—

The Commandant, a General Officer, usually of the Artillery or the Engineers, at present a General of Artillery.

A Second in Command, a Colonel or Lieutenant-Colonel, chosen from former pupils of school; at present a Colonel of Engineers.

Three Captains of Artillery and Three Captains of Engineers, as Inspectors of Studies, chosen also from former pupils of the school.

Six Adjutants (*adjoints*,) non-commissioned officers, usually such as have been recommended for promotion.

II. The civil establishment consists of:—

1. A Director of Studies, who has generally been a civilian, but is at present a Lieutenant-Colonel of Engineers.

2. Fifteen Professors, viz.:—Two of Mathematical Analysis. Two of Mechanics and Machinery. One of Descriptive Geometry. Two of Physics. Two of Chemistry. One of Military Art and Fortification. One of Geodesy. One of Architecture. One of French Composition. One of German. One of Drawing. Of these one is an officer of the Staff, another of the Artillery, and a third of the Navy; two are Engineers in Chief of the Roads and Bridges; nine are civilians, of whom two are Members of the Academy of Sciences.

3. Three Drawing Masters for Landscape and Figure Drawing; one for Machine Drawing, and one for Topographical Drawing.

4. Nineteen Assistant and Extra Assistant Teachers, (*répétiteurs* and *répétiteurs adjoints*) whose name and functions are both peculiar.

5. Five Examiners for Admission, consisting at present of one Colonel of Artillery, as President, and four civilians.

6. Five Examiners of Students (civilians,) four of them belonging to the Academy of Sciences.

7. There is also a separate Department for the ordinary Management of Administration of the affairs of the school, the charge of the fabric and of the library and museums; and a Medical Staff.

III. The general control or supervision of the school is vested, under the war department, in four great boards of councils, viz.:—

1. A board of administration, composed of the commandant, the second in command, the director of studies, two professors, two captains, and two members of the administrative staff. This board has the superintendence of all the financial business and all the minutiæ of the internal administration of the school.

2. A board of discipline, consisting of the second in command, the director, two professors, three captains (of the school,) and two captains of the army, chosen from former pupils. The duty of this board is to decide upon cases of misconduct.

3. A board of instruction, whose members are, the commandant, the second in command, the director, the examiners of students, and the professors; and whose chief duty is to make recommendations relating to ameliorations in the studies, the programmes of admission and of instruction in the school, to—

4. A board of improvement, charged with the general control of the studies, formed of—

The Commandant, as President.
The Second in Command.
The Director of Studies.
Two Delegates from the Department of Public Works.
One Delegate from the Naval Department.
One Delegate from the Home Department.
Three Delegates from the War Department.
Two Delegates from the Academy of Sciences.
Two Examiners of Students.
Three Professors of the School.

III. CONDITIONS AND EXAMINATIONS FOR ADMISSION.

The entrance examination is held yearly in August; the most important conditions for admission to it are always inserted in the *Moniteur* early in the year, and are—

1st. All candidates must be bachelors of science.

2nd. All candidates (unless they have served in the army) must have been as much as sixteen and not more than twenty years old on the 1st of January preceding.

3rd. Privates and non-commissioned officers of the army must be above twenty and under twenty-five years of age; must have served two years, and have certificates of good conduct.

4th. Candidates who propose to claim pecuniary assistance (a *bourse* or *demi-bourse*) must present formal proofs of their need of it.

The subjects of the entrance examination are the following:—

Arithmetic, including Vulgar and Decimal Fractions, Weights and Measures, Involution and Evolution; Simple Interest.

Geometry of Planes and Solids; application of Geometry to Surveying; Properties of Spherical Triangles.

Algebra, including Quadratic Equations with one unknown quantity, Series and Progressions in general; Binomial Theorem and its applications; Logarithms and their use; on Derived Functions; on the Theory of Equations; on Differences; application of the Theory of Differences to the Numerical Solution of Equations.

Plane and Spherical Trigonometry; Solution of Triangles; application of Trigonometry to Surveying.

Analytical Geometry, including Geometry of two dimensions; Co-ordinates; Equations of the first and second degree, with two variables; Tangents and Asymptotes; on the Ellipse, Hyperbola, and Parabola; Polar Co-ordinates; Curved Lines in general.

Geometry of three dimensions, including the Theory of Projections; Co-ordinates; the Right Line and Plane; Surfaces of the second degree; Conical and Cylindrical Surfaces.

Descriptive Geometry; Problems relative to a Point, Right Line and Plane; Tangent Planes; Intersection of Surfaces.

Mechanics; on the Movement of a Point considered geometrically; on the Effect of Forces applied to points and bodies at rest and moving; on the Mechanical Powers.

Natural Philosophy, including the Equilibrium of Liquids and Gasses; Heat;

Electricity; Magnetism; Galvanism; Electro-magnetism and Light; Cosmography.

Chemistry, the Elements; *French*; *German*; *Drawing*, and (optionally) *Latin*.

This examination is partly written and partly oral. It is not public, but conducted in the following manner:—

Five examiners are appointed by the minister of war to examine the candidates at Paris, and at the several towns named for the purpose throughout France.

Two of these examiners conduct what may be called a preliminary examination (*du premier degré*,) and the other three a second examination (*du second degré*.) The preliminary examiners precede by a few days in their journey through France those who conduct the second examination. The written compositions come before either.

The preliminary examination (*du premier degré*) is made solely for the purpose of ascertaining whether the candidates possess sufficient knowledge to warrant their being admitted to the second examination; and the second examination serves, in conjunction with the written compositions, for their classification in the order of merit.

Prior to the examination, each candidate is called upon to give in certain written sheets containing calculations, sketches, plans and drawings, executed by him at school during the year, certified and dated by the professor under whom he has studied. Care is taken to ascertain whether these are the pupils' own work, and any deception in this matter, if discovered, excludes at once from the competition of the school.

This done, the candidates are required to reply in writing to written or printed questions, and to write out French and German exercises; great care being taken to prevent copying. This written examination occupies about twenty-four hours during three and a half separate days, as shown in the following table. It usually takes place in the presence of certain official authorities, the examiners not being present.

First Sitting.	Hours.	*Second Sitting.*	Hours.
Arithmetic,	1	Algebra,	1
Geometry,	1	History, geography, and French,	3
Latin,	1		
	3		4
Third Sitting.		*Fourth Sitting.*	
Descriptive geometry, and diagram, or sketch,	4	Mechanics,	1
		Physics, chemistry, and cosmography,	2
			3

Fifth Sitting.	Hours.	*Sixth Sitting.*	Hours.
Applied analysis, - - -	1½	Solution of a triangle by logarithms, - - - - -	3
German exercise, - - -	1½		
	3		

Seventh Sitting.

Drawing, - - - - 4 hours.

Total, - - - - - 24 hours.

Next, each candidate is examined orally for three-quarters of an hour, on two successive days, by each of the two examiners separately, and each examiner makes a note of the admissibility or non-admissibility of the candidate.

At the close of this oral examination, the notes relating to the various candidates are compared, and if the examiners differ as to the admissibility of any candidate, he is recalled, further orally examined, and his written exercises carefully referred to, both examiners being present. A final decision is then made.

The preliminary examiners then supply the others with a list of the candidates who are entitled to be admitted to the second oral examination. On this occasion each candidate is separately examined for one hour and a half by each examiner, but care is taken that in all the principal subjects of study the candidate is examined by at least two out of the three examiners.

Each examiner records his opinion of the merits of every candidate in replying, orally and in writing, by awarding him a credit varying between 0 and 20, the highest number indicating a very superior result.

This scale of merit is employed to express the value of the oral replies, written answers, or drawings. It has the following signification, and appears to be generally in use in the French military schools:—

20	denotes perfect.	8, 7, 6	denotes bad.
19, 18	" very good.	5, 4, 3	" very bad.
17, 16, 15	" good.	2, 1	" almost nothing.
14, 13, 12	" passable.	0	" nothing.
11, 10, 9	" middling		

Considerable latitude is granted to the examiner engaged in deciding upon the amount of credit to be allowed to the student, for the manner in which he replies to the various questions. He is ex-

pected to bear in mind the temperament of the candidate, his confidence or timidity, as well as the difficulty of the questions, when judging of the quality of the reply, more value being given for an imperfect answer to a difficult question than for a more perfect reply to an easy one.

The reports of the examiners, together with the various documents belonging to each candidate, are sent from each town to the minister at war, who transmits them to the commandant of the Polytechnic School to make out a classified list.

Very different value of course is attached to the importance of some of the subjects, when compared with others; and the measure of the importance is represented in French examinations by what are termed *co-efficients of influence*, varying for the several subjects of study and kind of examination. The particular co-efficients of influence for each subject in these written and oral examinations, are as follows:—

	Co-efficients of Influence.	
Oral examination—analytical mathematics,	20	
" " geometrical ditto,	14	52
" " physics and mechanics,	16	
" " German language,	2	
Written compositions on mathematical subjects,	5	
" " descriptive geometry, drawing, and description,	5	
" " logarithmic calculations of a triangle,	2	
" " mechanics,	2	
" " physics or chemistry,	4	34
German exercise,	1	
French composition,	5	
Latin translation,	5	
Copy of a drawing,	5	
Total,		86

In order to make out the above mentioned classified list, the respective credits awarded by the examiners to each candidate are multiplied by the co-efficients representing the weight or importance attached to each subject; and the sum of their products furnishes a numerical result, representing the degree of merit of each candidate.

A comparison of these numerical results is then made, and a general list of all the candidates is arranged in order of merit.

This list, and the whole of the documents from which it has been drawn up, are then submitted to a jury composed of the

Commandant of the School.
The Second in Command.
The Director of Studies.
Two Members of the Board of Improvement.
The Five Examiners.

It is the special business of this jury carefully to scrutinize the whole of the candidates' documents, drawings, &c., and they further take care that a failure in any one branch of study is duly noted, as such failure is a sufficient reason for the exclusion of the candidate from the general list.

As soon as this general list has been thoroughly verified, it is submitted to the minister of war, who is empowered to add one-tenth to the number actually required for the public services; and thus it may happen that one-tenth of the pupils may annually be disappointed.

IV. THE SCHOOL BUILDINGS AND THE COURSE AND METHOD OF STUDY.

A brief description of the buildings may be a suitable introduction to an account of the studies that are pursued, and the life that is lead in them.

The Polytechnic School stands near the Pantheon, and consists of two main buildings, one for the official rooms and the residence of the commandant and director of studies, the other, and larger one, for the pupils. Detached buildings contain the chemical lecture room and laboratory, the laboratory of natural philosophy, the library, fencing and billiard rooms.

The basement floor of the larger building contains the kitchen and refectories. On the first floor, are the two amphitheaters or great lecture rooms, assigned respectively to the pupils of the two years or divisions, in which the ordinary lectures are given. The rooms are large and well arranged; the seats fixed, the students' names attached to them. The students are admitted by doors behind the upper tier of seats; at the foot of all is a platform for the professor, with a blackboard facing his audience, and with sufficient room for a pupil to stand and work questions beside him. Room also is provided for one of the captains, inspectors of studies, whose duty it is to be present, for the director of studies, whose occasional presence is expected, and for the assistant teachers or *répétiteurs*, who in the first year of their appointment are called upon to attend the course upon which they will have to give their subsequent questions and explanations. On this floor are also the museums, or repositories of models, instruments, machines, &c., needed for use in the amphi theaters, or elsewhere. The museum provided for the lecturer on Physics (or Natural Philosophy) appeared in particular to be well supplied.

The whole of the second floor is taken up with what are called the *salles d'interrogation*, a long series of small cabinets or studies,

plainly furnished with six or eight stools and a table, devoted to the *interrogations particulières*, which will presently be described.

The third floor contains the halls of study, *salles d'étude*, or studying rooms, in which the greater part of the student's time during the day is passed—where he studies, draws, keeps his papers and instruments, writes his exercises, and prepares his lectures. These are small chambers, containing eight or, exceptionally, eleven occupants. A double desk runs down the middle from the window to the door, with a little shelf and drawers for each student. There is a blackboard for the common use, and various objects are furnished through the senior student, the sergeant, a selected pupil, more advanced than the rest, who is placed in charge of the room, and is responsible for whatever is handed in for the use of the students. He collects the exercises, and generally gives a great deal of assistance to the less proficient. "When I was sergeant," said an old pupil, "I was always at the board." The spirit of *camaraderie*, said to exist so strongly among the Polytechnic students, displays itself in this particular form very beneficially. Young men of all classes work heartily and zealously togethen in the *salles d'étude*, and no feeling of rivalry prevents them from assisting one another. The sergeant does not, however, appear to exercise any authority in the way of keeping discipline.

These chambers for study are arranged on each side of a long corridor which runs through the whole length of the building, those of the juniors being separated from those of the seniors by a central chamber or compartment, the *cabinet de service*, where the officers charged with the discipline are posted, and from hence pass up and down the corridor, looking in through the glass doors and seeing that no interruption to order takes place.

The fourth story is that of the dormitories, airy rooms, with twelve beds in each. These rooms are arranged as below, along the two sides of a corridor, and divided in the same manner into the senior and junior side. A non-commissioned officer is lodged at each end of the corridor to see that order is kept.

Such is the building into which at the beginning of November the successful candidates from the *Lycées* and the *Ecoles préparatoires* are introduced, in age resembling the pupils whom the highest classes of English public schools send annually to the universities, and in number equal perhaps to the new under-graduates at one of the largest colleges at Cambridge. There is not, however, in other points much that is common, least of all in the methods

and habits of study we are about to describe. This will be best understood by a summary of a day's work.

The students are summoned to rise at half-past five, have to answer the roll-call at six, from six to eight are to occupy themselves in study, and at eight they go to breakfast. On any morning except Wednesday, at half-past eight, we should find the whole of the new admission assembled in an amphitheater, permanent seats in which are assigned to them by lot, and thus placed they receive a lecture from a professor, rough notes of which they are expected to take while it goes on. The first half hour of the hour and a half assigned to each lecture is occupied with questions put by the professor relating to the previous lecture. A name is drawn by lot, the student on whom the lot falls is called up to the blackboard at which the professor stands, and is required to work a problem and answer questions. The lecture concluded, the pupils are conducted to the *salles d'étude*, which have just been described, where they are to study. Here for one hour they devote themselves to completing and writing out in full the notes of the lecture they have just heard. The professor and his assistants, the *répétiteurs*, are expected to follow and make a circuit through the corridors, to give an opportunity to ask for information on any difficult points in the lecture. A lithographed summary of the substance of the lecture, extending perhaps to two octavo pages, is also furnished to each studying room for the use of its pupils.

The lecture, as we have said, commences at half-past eight o'clock; it lasts an hour and a half; the hour of writing up the notes brings us to eleven. The young men are now relieved by a change of occupation, and employ themselves (still in their places in the rooms of study) at drawing. A certain number, detached from the rest, are sent to the physical and chemical laboratories. The rotation is such as to admit each student once a month to two or three hours' work at a furnace for chemistry, and once in two months to make experiments in electricity, or other similar subjects. In this way, either at their drawing or in the laboratories, they spend three hours, and at two o'clock go to their dinner in the refectories below, and after dinner are free to amuse themselves in the court-yard, the library, the fencing and the billiard rooms, till five. At five they return to the studying rooms, and for two hours, on Mondays and Fridays, they may employ themselves on any work they please (*étude libre;*) on Tuesday there is a lecture in French literature, and on Thursday in German; at seven o'clock they commence a lesson, which lasts till nine, in landscape and figure drawing, or they

do exercises in French writing or in German; at nine they go down to supper; at half-past nine they have to answer to a roll-call in their bedrooms, and at ten all the lights are put out.

Wednesday is a half-holiday, and the pupils are allowed to leave the school after two o'clock, and be absent till ten at night. The morning is occupied either in study, at the pleasure of the students, or in set exercises till eleven, when there is a lecture of one hour and a half, followed, as usual, by an hour of special study on the subject of the lecture. On Sunday they are allowed to be absent almost the whole day till ten P. M. There is no chapel, and apparently no common religious observance of any kind in the school.

Such is a general sketch of the ordinary employment of the day; a couple of hours of preparatory study before breakfast, a lecture on the differential calculus, on descriptive geometry, on chemistry, or natural philosophy, followed by an hour's work at notes; scientific drawing till dinner; recreation; and general study, or some lighter lecture in the evening. Were we merely to count the hours, we should find a result of eleven or eleven and a half hours of work for every day but Wednesday, and of seven and a half hours for that day. It is to be presumed, however, that though absolute idleness, sleeping, or reading any book not authorized for purposes of study, is strictly prohibited, and when detected, punished, nevertheless the strain on the attention during the hours of drawing and the lectures of the evening is by no means extreme. Landscape and figure drawing, the lecture in French literature, and probably that in German, may fairly be regarded as something like recreation. Such, at least, was the account given us of the lectures on literary subjects, and it agrees with the indifference to literature which marks the school. Of wholesome out-of-door recreation, there certainly seems to be a considerable want. There is nothing either of the English love of games, or of the skillful athletic gymnastics of the German schools.

The method of teaching is peculiar. The plan by which a vast number of students are collected as auditors of professorial lectures is one pursued in many academical institutions, at the Scotch universities, and in Germany. Large classes attend the lectures in Greek, in Latin, and in mathematics at Glasgow; they listen to the professor's explanations, take notes, are occasionally questioned, and do all the harder work in their private lodgings. Such a system of course deserves in the fullest sense the epithet of voluntary; a diligent student may make much of it; but there is nothing to compel an idle one to give any attention.

It seems to have been one especial object pursued in the Polytechnic to give to this plan of instruction, so lax in itself, the utmost possible stringency, and to accumulate upon it every attainable subsidiary appliance, every available safeguard against idleness. Questions are expressly put *vivâ voce* by the professor before his lecture; there is a subsequent hour of study devoted to the subject; there is the opportunity for explanation to individual students; the exaction of notes written out in full form; the professor also gives exercises to the students to write during their hours of general study, which he examines, and marks; general vivâ voce examinations (*interrogations générales*,) conducted by the professors and *répétiteurs*, follow the termination of each course of lectures; and lastly, one of the most important and peculiar parts of the method, we have what are called the *interrogations particulières*. After every five or six lectures in each subject, each student is called up for special questioning by one of the *répétiteurs*. The rooms in which these continual examinations are held have been described. They occupy one entire story of the building; each holds about six or eight pupils, with the *répétiteurs*. Every evening, except Wednesday, they are filled with these little classes, and busy with these close and personal questionings. A brief notice, at the utmost of twenty-four hours, is served upon the students who are thus to be called up. Generally, after they have had a certain number of lectures, they may expect that their time is at hand, but the precise hour of the summons can not be counted upon. The scheme is continually varied, and it defies, we are told, the efforts of the ablest young analysts to detect the law which it follows.

It will be seen at once that such a system, where, though nominally professorial, so little is left to the student's own voluntary action, where the ordinary study and *reading*, as it is called in our English universities (here such an expression is unknown) is subjected to such unceasing superintendence and surveillance, and to so much careful assistance, requires an immense staff of teachers. At the Polytechnic, for a maximum of 350 pupils, a body of fifteen professors and twenty-four *répétiteurs*, are employed, all solely in actual instruction, and in no way burdened with any part of the charge of the discipline or the finance, or even with the great yearly examinations for the passage from the first to the second division, and for the entrance to the public services.

With a provision of one instructor to every eight students, it is probable that in England we should avoid any system of large classes, from the fear of the inferior pupils being unable to keep

pace with the more advanced. We should have numerous small classes, and should endeavor, above all things, to obtain the advantage of equality of attainment in the pupils composing them.

The French, on the other hand, make it their first object to secure one able principal teacher in each subject, a professor whom they burden with very few lectures. And to meet the educational difficulty thus created, to keep the whole large class of listeners up to the prescribed point, they call in this numerous and busily employed corps of assistants to *repeat*, to go over the professor's work afresh, to whip in, as it were, the stragglers and hurry up the loiterers. Certainly, one would think, a difficult task with a class of 170 freshmen in such work as the integral and differential calculus. It is one, however, in which they are aided by a stimulus which evidently acts most powerfully on the students of the Polytechnic School. During the two years of their stay, the prospect of their final admission to the public services can rarely be absent from the thoughts even of the least energetic and forethinking of the young men. Upon their place in the last class list will depend their fortune for life. A high position will secure them not only reputation, but the certainty of lucrative employment; will put it in their power to select which service they please, and in whichever they choose will secure them favorable notice. Let it be remembered that fifty-three of these one hundred and seventy are free scholars, born of parents too poor to pay 40*l.* a year for their instruction, to whom industry must be at all times a necessity, and industry during their two years at the Polytechnic the best conceivable expenditure, the most certainly remunerative investment of their pains and labor. The place on the final class list is obviously the prize for which this race of two years' length has to be run. What is it determines that place? Not by any means a final struggle before the winning-post, but steady effort and diligence from first to last throughout the course. For the order of the class list is not solely determined by success in the examination after which it is drawn up, but by the result of previous trials and previous work during the whole stay at the school.

For, during the whole time, every written exercise set by the professor, every drawing, the result of every *interrogation particulière* by the *répétiteurs*, and of each general interrogation by the professors and *répétiteurs*, is carefully marked, and a credit placed according to the name of the student and reserved for his benefit in the last general account. The marks obtained in the examination which closes the first year of study form a large element

in this last calculation. It had been found that the work of the first year was often neglected: the evil was quickly remedied by this expedient. The student, it would seem, must feel that he is gaining or losing in his banking account, so to call it, by every day's work; every portion of his studies will tell directly for or against him in the final competition, upon which so much depends.

Such is the powerful mechanism by which the French nation forces out of the mass of boys attending their ordinary schools the talent and the science which they need for their civil and military services. The efforts made for admission to this great scientific school of the public services, the struggle for the first places at the exit from it, must be more than enough, it is thought, to establish the habits of hard work, to accumulate the information and attainment, and almost to create the ability which the nation requires for the general good.

We may now follow the student through his course of two years' study. The first year's work may be mainly divided into three portions of unequal length; two of them of about four months each (with an additional fortnight of private study and examination,) are mainly given to hard lecturing, whilst the third portion of two months is devoted to private study and to the examinations.

In accordance with this arrangement of the year, the four hardest subjects are thus distributed. Analysis and descriptive geometry, the staple work of the school—its Latin, as M. de Barante called it—come in the first four months; there is then a pause for private study and a general examination in these two subjects (*interrogations générales* as distinct from the *interrogations particulières* of the *répétiteurs*.) This brings us to the middle of March. Analysis and geometry are then laid aside for the rest of the year, and for the next portion of four months the pupils work at mechanics and geodesy, private study and a general examination completing this course also. Important lectures on physics and chemistry run on during both these periods, and are similarly closed by private study and a general examination. The less telling evening classes of French literature and German end at the beginning of June, and landscape and figure drawing only last half the year. It may be observed also, that, as a general rule, there is on each day one, and only one, really difficult lecture. This is immediately preceded and followed by private study, but then comes something lighter, as a relief, such as drawing or work in the laboratories.

The chief feature in the third portion of the year is the complete break in the lectures for general private study (*étude libre*,) a month

or six weeks before the closing examination at the end of the year. The immediate prospect of this prevents any undue relaxing of the work; and it is curious to observe here how private efforts and enforced system are combined together, for even the private efforts are thus systematized and directed. The closing examination of the first year begins on the 1st and ends on the 25th of September.

The total number of lectures in each branch of study, with the dates when they respectively commence and finish, and the period when the general examinations (*interrogations générales*) take place, are exhibited in the following tables, and we should add that the interval between the close of each course and the commencement of the chief yearly examination is devoted to free study.

TABLE FOR THE SECOND OR LOWER DIVISION, FOLLOWING THE FIRST YEAR'S COURSE OF STUDY.

Subject of Study.	No. of Lectures.	Course of Lectures.		General Examinations. *Interrogations Générales.*		Annual Examination.
		Commenced.	Finished.	Commenced.	Finished.	
Analysis,	48	3rd Nov.	25th Feb.	13th March.	18th March.	Begins on the 1st Sept., and ends on the 25th Sept.
Mechanics and Machines,	40	21st March.	29th June.	24th July.	2nd August.	
Descriptive Geometry,	38	3rd Nov.	3rd March.	13th March.	18th March.	
Physics,	34	2nd "	28th June.	10th July.	19th July.	
Chemistry,	38	5th "	17th "	10th "	19th "	
Geodesy,	35	20th March	30th "	24th "	2nd August.	
French Literature,	30	8th Nov.	6th "			
German,	30	2nd "	15th "			
Figure and Landscape Drawing,	50	4th "	28th April.			
Total,	343					

The work of the second year is almost identical in its general plan with that of the first. A continuation of analysis with mechanics in place of descriptive geometry is the work of the first four months, then comes the private study and the *interrogations générales*, and then again, from the middle of March to the middle of July, work of a more professional character, stereotomy, the art of war and topography, forms the natural completion of the pupil's studies. Chemistry and physics follow the same course as during the first year, and terminate with the private study and the general examination at the beginning of August. The evening lectures in French literature and German end about the middle of June, and those in figure and landscape drawing at the beginning of May. The last portion is again given to private study and the great Final Examination.

TABLE FOR THE FIRST OR UPPER DIVISION, FOLLOWING THE SECOND YEAR'S COURSE OF STUDY.

Subject of Study.	No. of Lectures.	Course of Lectures.		General Examinations. *Interrogations Générales.*		Annual Examination.
		Commenced.	Finished.	Commenced.	Finished.	
Analysis,	32	11th Nov.	3rd March.	13th March.	18th March.	Begins on the 10th Sept. and ends on the 10th Oct.
Mechanics and Machines,	42	10th "	2nd "	13th "	18th "	
Stereotomy,	32	20th March.	29th June.	10th July.	19th July.	
Physics,	36	12 Nov.	29th "	24th "	2nd Aug.	
Chemistry,	38	14th "	28th "	24th July.	2nd "	
Architecture and Construction,	40	10th "	8th "	.....	.....	
Military Art and Fortification,	20	21st March.	21st "	10th "	19th July.	
Topography,	10	3rd Jan.				
French Literature,	30	11th Nov.	9th "			
German,	30	14th "	19th "			
Figure and Landscape Drawing,	48	12th "	2nd May.			
Total,	358					

V. THE EXAMINATIONS, PARTICULARLY THAT OF THE FIRST YEAR AND THE FINAL ONE.

We have now brought the pupil nearly to the end of his career, but must previously say a few words about his examinations, the chief epochs which mark his progress, and the last of which fixes his position almost for life. For this purpose it is necessary to recapitulate briefly what has been said in different places of the whole examinatorial system of the Polytechnic School.

1. All the professors require the students in their studying rooms, to answer questions in writing on the courses as they go through them: a different question is given to each student, and every third question is of such a nature as to involve a numerical example in the reply.

These questions are given in the proportion of one to about every four lectures, and the replies after being examined by the professor or *répétiteur*, are indorsed with a credit, varying from 0 to 20, and the paper is then given back to the student, to be produced at the close of the year.

2. Credits are assigned to the students for their ordinary manipulations in chemistry and physics, during the first year; and at the close of each year, for their manipulations, in chemistry alone, before the examiners.

3. The *répétiteurs* examine, (in the *interrogations particulières*,) every ten or fourteen days, from six to eight students during a sitting of two hours, on the subject of study lectured on since the previous examination of the same kind. All these students must continue present, and at the close the *répétiteur* assigns to each a

previous examination of the same kind. All these students must continue present, and at the close the *répétiteur* assigns to each a credit entirely dependent on the manner in which each has replied. The professors and captains inspectors are occasionally present at these examinations, which are discontinued at certain periods according to the instructions of the director of studies.

4. At different intervals of time, from a fortnight to a month, as may happen, after the close of the course in each branch of study, general examinations (*interrogations générales*) are made by the professors and *répétiteurs*. From four to six students are examined together for at least two hours, and at the conclusion the professor makes known to the director of studies the credit he has granted to each student for the manner in which he has passed his examination.

Such may be called the minor or ordinary examinations. But there is an annual closing examination at the end of each year, which we will now describe. The first year's annual examination commences on the 1st and ends on the 25th September. It is carried on by special examiners, (a different set from those who conduct the entrance examinations,) and not by the professors. These give to every student a credit between 0 and 20 in each branch of study, according to the manner in which he replies.

The following table shows the co-efficients of influence allowed to the different studies of the first year, subdivided also among the particular classes of examination to which the student has been subjected. The component parts of the co-efficients as well as the co-efficients themselves, slightly vary from year to year, dependent on the number of examinations:—

TABLE I.—FIRST YEAR'S COURSE OF STUDIES: SECOND DIVISION.

Nature of Study.	Total Co-efficients.	Co-efficient of Influence awarded to								
		Written Answers to Professors' Questions.	Examinations by *Répétiteurs*. (*Int. Part.*)	General Examinations. (*Int. Gén.*)	Manipulations. Ordinary.	Manipulations. At Examinations.	Sheets of notes on descriptive Geometry.	Graphical Representations and Drawing.	First Annual Examination.	Total Co-efficients.
Analysis,	56	9	10	9	..	..	..	..	28	56
Mechanics,	60	7	9	8	..	..	..	14	22	60
Descriptive Geometry,	48	..	7	7	..	..	4	12	18	48
Geodesy,	39	6	5	7	..	..	..	3	18	39
Physics,	45	6	9	7	2	..	..	..	21	45
Chemistry,	45	5	9	7	4	2	..	..	18	45
French Literature,	12	12	..	..	..	..	..	..	..	12
German Language,	10	2	3	..	..	..	..	..	5	10
Drawing,	10	..	..	..	..	..	..	10	..	10
Shading and Tinting Plans,	3	..	..	..	..	..	..	3	..	3

At the conclusion of this examination the director of studies pre

pares a statement for each student, exhibiting the credits he has obtained at each of the preceding examinations in each subject, multiplied by the co-efficient of influence, and the sum of the products represents the numerical account of the student's credit in each branch of study.

As the process is somewhat intricate, we append the following example, to show the nature of the calculation performed, in order to ascertain the amount of credits due to each student:—

REPORT OF THE CREDITS GAINED IN THE FIRST YEAR'S COURSE OF STUDY BY M. N., STUDENT AT THE POLYTECHNIC SCHOOL.

Subject of Examination.	Co-efficient of Influence.	Nature of Examination or Proof.	Credit obtained by the Student.	Co-efficients of Influence.	Product.	Sum of Products.	Mean Credit in each Subject of the Course.
Analysis,	56	Written answers to Professors' questions,	17.16	9	154.44	845.81	15.09
		Examinations by *répétiteurs* (*interrogations particulières,*)	15.47	10	154.70		
		General Examination (*interrogations générales,*)	13.71	9	123.39		
		Annual Examination,	14.75	28	413.28		
Mechanics,	60	Written answers to Professors' questions,	13.45	7	94.15	664.13	11.07
		Examinations by *répétiteurs*,	12.72	9	114.48		
		General examination,	11.37	8	90.96		
		Graphical representations and drawing,	5.61	14	78.54		
		Annual examination,	13.00	22	286.00		
Descriptive Geometry,	48	Examinations by *répétiteurs*,	17.15	7	120.05	633.15	13.19
		General examination,	11.72	7	82.04		
		Sheets of notes,	12.45	4	49.80		
		Graphical rep. and drawing,	11.88	12	142.76		
		Annual examination,	13.25	18	238.50		
Geodesy,	39	Written answers to Professors' questions,	9.16	6	54.96	229.01	5.87
		Examinations by *répétiteurs*,	7.85	5	39.25		
		General examination,	5.74	7	40.18		
		Graphical rep. and drawing,	4.36	3	13.08		
		Annual examination,	4.53	1	81.54		
Physics,	45	Written answers to Professors' questions,	2.76	6	16.56	112.21	2.49
		Examinations by *répétiteurs*,	3.54	9	31.86		
		General examination,	3.15	7	22.05		
		Ordinary manipulation,	1.55	2	3.10		
		Annual examination,	1.84	21	38.64		
Chemistry,	45	Written answers to Professors' questions,	2.46	5	12.30	131.16	2.91
		Examinations by *répétiteurs*,	3.25	9	29.25		
		General examination,	2.47	7	17.29		
		Ordinary manipulation,	2.26	4	9.04		
		Manipulation at examination,	1.58	2	3.16		
		Annual examination,	3.34	18	60.12		
French Literature,	12	Written answers to Professors' questions,	5.64	12	67.68	67.68	5.64
German Language,	10	Written answers to Professors' questions,	6.57	2	13.14	55.92	5.59
		Examinations by *répétiteurs*,	4.86	3	14.58		
		Annual examination,	5.64	5	28.20		
Drawing,	10	Graphical representations and drawing,	4.36	10	43.60	43.60	4.36
Shading and Tinting Plans,	3	Graphical representations and drawing,	3.86	3	11.58	11.58	3.86
					Sum,		10)70.07
					General Mean Credit, =		(7.00)

It is important to remark that any student whose *mean credit*, given in the eighth column of the preceding table, in any branch of study does not exceed *three*, or whose *general mean credit* for the whole of the studies being the arithmetical mean of all the values recorded in the eighth column, and given at the bottom in the example, does not exceed six, is *considered to possess an insufficient amount of instruction to warrant his being permitted to pass into the first division for the second year's course.* He is accordingly excluded from the school, unless he has been prevented from pursuing his studies by illness, in which case, when the facts are thoroughly established, he will be allowed a second year's study in the second division, comprising the first year's course of study.

We now pass to the second annual or great final examination for admission to the public services, remarking only that in the *interrogations générales* of the second year the principal subjects of both years are included.

The final examinations for admission into the public service commence about the 10th September, and last about one month. They are conducted by the same examiners who examined at the close of the first year. These are five in number, and appointed by the minister of war. One of these takes analysis; a second, mechanics; a third, descriptive geometry and geodesy; the fourth, physics; and the fifth, chemistry.

The examination in military art and topography is conducted by a captain of engineers specially appointed for the purpose; and in the same manner the examination in German is carried on by a professor, usually a civilian, specially but not permanently appointed.

The questions are oral, and extend over the whole course of study pursued during the two years. Each student is taken separately for one hour and a quarter on different days by each of the five examiners; each examiner examines about eight students daily.

A table, very similar to that already given, is prepared under the superintendence of the Director of studies for every student, to ascertain the numerical amount of his credits in each branch of study, the co-efficients of influences for the particular subject of study and nature of examination being extracted from a table similar to that in page 80, and when these tables have all been completed, a general list of all the students is made out, arranged in the order of their merits.

Formerly, conduct was permitted to exercise some slight influence on their position, but that is no longer the case.

The same regulations exist, as regards the minimum amount of

credit that will entitle the students to enter into the public service, as have already been stated above in reference to the passage from the first to the second year's course of study.

TABLE II. SECOND YEAR'S COURSE OF STUDY: FIRST DIVISION.

	Total Co-efficients.	Co-efficient of Influence awarded to										
		Result of previous Year's Examination.	Written answers to Professors' Questions.	Examinations by *Répétiteurs.* (*Int. Part.*)	General Examinations. (*Int. Gén.*)	Manipulation. Ordinary.	Manipulation. At Examinations.	Sketches and Notes in Architecture.	Graphical Representations and Drawing.	Examination in Architecture.	Second Annual or Final Examination.	Total Co-efficients.
Analysis,	81	28	8	10	9	....	....	.....	.....	....	26	81
Mechanics,	92	25	8	12	9	....	....	.....	10	....	28	92
Descriptive Geometry,	36	36	.....	.....	.....	....	....	.....	.....	....	.....	36
Geodesy,	37	.....	6	5	7	....	....	.....	1	....	18	37
Physics,	68	23	5	10	8	....	....	.....	.....	....	22	68
Chemistry,	68	20	5	10	8	4	2	.....	.....	....	19	68
Architecture,	36	.....	.....	.....	.....	....	....	12	14	10	.....	36
Military art and Topography,	25	.....	.....	3	5	....	....	.....	9	....	8	25
French Literature,	18	6	12	.....	.....	....	....	.....	.....	....	.....	18
German,	15	5	2	3	.....	....	....	.....	.....	....	.....	15
Drawing,	15	5	.....	.....	.....	....	....	.....	10	....	.....	15
Shading and Tinting,	5	2	.....	.....	.....	....	....	.....	3	....	.....	5

From the preceding tables and explanations, it will be apparent that, as the whole of the students for each year are compelled to follow precisely the same course of study, the system of professorial instruction, combined with the constant tutelage and supervision exercised by the *répétiteurs*, and the examinations (*interrogations particulières*) of the *répétiteurs*, at short intervals of time, have for their principal object the keeping alive in the minds of the students the information which has been communicated to them. As a stimulus to continuous and unceasing exertion, it will be seen by an inspection of the tables of the co-efficients of influence, that the manner in which the students acquit themselves from day to day, and from week to week, is made an element, and a very important one, in determining their final position in the list arranged according to merit, exceeding as it does in most instances the influence exerted on their classification by their final examination at the close of each year. This principle thus recognizes not only their knowledge at the end of each year, but also the manner in which they have proved it to the professors and *répétiteurs* in the course of the year; and with reference to the second year's study, the final result of the first year's classification exercises an influence amounting to

about one-third of the whole, in the final classification at the end of the second year.

It follows also, that as the examinations at the end of each year are made by examiners, otherwise unconnected with the school, and not by the professors belonging to it, the positions of the students in the classified list is partly dependent on the judgment of the professors with whom they are constantly in communication, and partly on the public examiners, whom they meet only in the examination rooms.*

The examiners of the students are not frequently changed, and practically the same may be said of the examiners for admission.

The students at the head of the list have generally since the wars of the first Empire entered into the civil rather than into the military services, the former being much better remunerated.

The services are usually selected by preference, nearly in the following order:—

The Roads and Bridges (*Ponts et chaussées*) and Mines (*Mines*,) - - - - - } very nearly on an equality.

Powder and Saltpetre (*Poudres et Salpêtres.*)

Naval Architects (*Génie maritime.*)

Engineers (*Génie militaire.*)

The Artillery (*Artillerie de terre*,) and the Staff Corps (*Etat Major*,) } very nearly on an equality.

The Hydographical Corps (*Ingénieurs Hydrographes.*)

Subjects of Study.	Per-centage of influence exercised on the position of the Students.							
	During the 1st Year.		During the 2nd Year.			In the Classified List at the end of 2nd year.	
	By Professors and *Répétiteurs.*	By Examiners.	By the results of the first Year's Examination.	By Professors and *Répétiteurs.*	By Examiners.	By Professors and *Répétiteurs.*	By Examiners.
Analysis,	50.0	50.0	34.5	32.5	33.0	49.75	50.25
Mechanics,	62 2	38.7	27.2	42.4	30.4	59.6	40.40
Descriptive Geometry,	62.5	37.5	100.0	0.0	0.0	62.5	37.5
Geodesy,	53.8	46.2	0.0	51.4	48.6	*51.4	48.6
Physics,	53.3	46.7	33.8	33.8	32.4	51.8	48.2
Chemistry,	60.0	40.0	29.4	43.2	27.4	60.8	39.2
Architecture,	.....	.....	0.0	100.0	0.0	100.0	100.0
Military Art and Topography,	.....	.....	0.0	68.0	32.0	68.0	32.0
French Literature,	100.0	0.0	33.3	66.7	0.0	100.0	0.0
German Language,	100.0	0.0	33.3	33.3	33.4	66.7	33.3
Drawing,	100.0	0.0	33.3	66.7	0.0	100.0	0.0
Shading and Tinting Plans,	100.0	0.0	40.0	60.0	0.0	100.0	0.0
					*	* When taught in the 2nd year.	

* The influence exercised in the various branches of study, and consequently in the position of the students in the list classified according to merit, by the professors and *répétiteurs* on the one hand, and by the examiners on the other, as in the table above.

Tobacco Department (*Administration des Tabacs.*)
Telegraph Department (*Lignes Télégraphiques.*)
Navy (*Marine.*)
Marine Artillery (*Artillerie de mer.*)

Such, at least, is the result of a comparison of the selections made by the students during eight different years.

This preference of the civil to the military services has been the subject of frequent complaints on the part of the military authorities to the minister of war.

No steps have, however, been taken by the French government to prevent the *free* choice of a profession being granted to the most successful students.

We have now followed the student at the Polytechnic to the end of his school career. He is then to pass to his particular School of Application, in which (as the name implies) he is taught to apply his science to practice. It is difficult to state precisely the amount of such science which the highest pupils may be thought to possess on leaving; the best idea of it will be gained by reference to the programmes of the most important of the lectures. It is also needless to dwell again on the main features of the school—the emulation called forth, the minute method, the great prizes offered for sustained labor. We must, however, make some remarks on these points before concluding our account, so far as they bear on the subject of military education.

VI. GENERAL REMARKS.

1. Keeping out of sight for the moment some defects both in the principles and details of the education of this school, the method of teaching adopted seems to us excellent, and worthy of careful study. In this remark we allude principally to the skillful combination of two methods which have been generally thought incompatible; for it unites the well-prepared lecture of a German professor, with the close personal questioning of a first-rate English school or college lecture. But besides this, its whole system is admirably adapted for the class of pupils it educates.

These pupils are generally not of the wealthy classes; they are able, and struggling for a position in life. On all these grounds their own assistance in the work may be calculated upon. Yet they are not left to themselves to make the most of their professors' lectures. The aid of *répétiteurs*, even more valuable in its constant "prudent interrogations," than in the explanations afforded, is joined to the stimulus given by marking every step of proficiency, and by making all tell on the last general account. But though the routine and method of the school are so elaborate, play is given to the individual freedom of the pupils in their private work, and this is managed so skillfully that the private work is made immediately to precede the final examination, on which mainly depends the pupil's place for life. Thus from first to last they are carried on by their system without being cramped by it; every circumstance favorable to study is made the most of; rigorous habit, mental readiness,

the power of working with others, and the power of working for themselves, the ambition for immediate and permanent success, all the objects and all the methods which students ever have in view, support and stimulate those of the Polytechnic in their two years' career.

2. The mainspring, however, of the school's energy is the competition amongst the pupils themselves, and this could hardly exist without the great prizes offered to the successful. This advantage, added to the general impulse of the early days of the Empire, has no doubt powerfully contributed to the great position of the school. It has made it a kind of university of the *élite* mathematicians, and as in England young men look to the prizes of the universities, and the professions to which they lead, as their best opening in life, so in France, ever since the first revolution, the corresponding class has inclined to the active and chiefly military career which is offered by the great competitive school of the country.

3. A preparatory school of this remarkable character can not but exercise a very powerful influence over those three-fourths of its pupils who leave it to enter the army. The obvious question is whether the attempt is not made to teach more than is either necessary or desirable for military purposes, and to this suspicion may be added the fact that the civil prizes being more in request than the military, many of those who enter the army do so in the first instance reluctantly, and that the pupils at the bottom of the list appear to be often such marked failures as to imply either great superficiality or premature exhaustion.

4. In studying the Polytechnic School we have had these points constantly brought before us, and feeling the difficulty of discussing them fully, we beg to invite attention to the evidence sent us in reply to some questions which we addressed on the subject to some distinguished scientific officers and civilians connected with the school. We will give briefly the result of our own inquiries.

5. The complaint of General Paixhans has been quoted. He urges that a considerable proportion of the army pupils are mere *queues de promotion*, and quite insufficient to form *le corps et surtout la tête* of troops *d'élite*.

Other not inconsistent complaints we heard ourselves, of the mental exhaustion and the excessively abstract tendencies of many of the military pupils of the school.

6. Such are the complaints. There is certainly reason to think that, with regard to the twenty or thirty lowest pupils on the list, those of General Paixhans are well founded. These are the *breaks down*, and we are at first surprised that, entering as they must do,* with high attain-

* The students are selected, by a competitive examination, out of a very large number of candidates, as will be seen from the following table, extracted from the yearly calendars :—

Year.	Candidates who inscribed their Names.	Candidates examined.	Candidates admitted to the Polytechnic.	Year.	Candidates who inscribed their Names.	Candidates examined.	Candidates admitted to the Polytechnic.
1832	567	468	183	1839	530	531	135
1833	367	304	110	.....	.....	.....	.....
1834	627	541	150	1842	709	559	137
1835	729	633	154	1843	802	559	166
.....	.....	.....	.....	1844	746	531	143
1837	629	508	137	1845	780	559	136
1838	533	410	131				

Giving an average of one student for four candidates *examined*, so that it is impossible to imagine that there is any lack of ability in those selected.
A similar result appears to follow from some other more recent statistics.

ments, they should fall so low as the marks in the tables (with which we are most liberally supplied) prove to be the case.

At the same time, we believe that no teaching ever has provided or will provide against many failures out of one hundred and seventy pupils, even among those who promised well at first: and if the standard of the majority of pupils is high at the Polytechnique, and the point reached by the first few *very* high, it is no reproach that the descent amongst the last few should be very rapid.

With regard to the assertion, that the teaching is excessive and leads too much to abstract pursuits for soldiers, it may be partially true. Perhaps the general passion for science has led to an overstrained teaching for the army, even for its scientific corps; and yet would it be allowed by officers of the highest scientific ability, either in the French or the English army, that less science is required for the greatest emergencies of military than for those of civil engineering, or for the theory of projectiles than for working the department of saltpetre?

It may, however, be true that an attempt is made at the Polytechnic to exact *from all* attainments which can only be reached by *a few*.

7. With this deduction, we must express our opinion strongly in favor of the influence of the Polytechnic on the French army. We admit that in some instances pupils who have failed in their attempt at civil prizes enter the army unwillingly, but they are generally soon penetrated with its *esprit de corps*, and they carry into it talent which it would not otherwise have obtained. Cases of overwork no doubt occur, as in the early training for every profession, but (following the evidence we have received) we have no reason to think them so numerous as to balance the advantage of vigorous, thoughtful study directed early towards a profession which, however practical, is eminently benefited by it. "It can not be said," was the verdict of one well fitted to express an opinion, "that there is too much science in the French army."

8. Assuming, however, the value of the scientific results produced in the French army by the Polytechnic, it by no means follows that a similar institution would be desirable in another country. Without much discussion it may be safely said that the whole history and nature of the institution—the offspring of a national passion for system and of revolutionary excitement—make it thoroughly peculiar to France.

9. Some obvious defects must be noticed. The curious rule of forbidding the use of *all* books whatever is a very exaggerated attempt to make the pupil to rely entirely on the professors and *répétiteurs*. The exclusive practice of *oral* examination also seems to us a defect. Certainly every examination should give a pupil an opportunity of showing such

Year.	Number of Candidates who inscribed their Names.	Number declared admissible to the Second Examination.	Number admitted.
1852	510	216	202
1853	494	222	217
1854	519	238	170
1855	544	233	170

In judging, however, of these numbers, it should be borne in mind that a very large number of the candidates who succeed have tried more than once; the successful of this year have been among the unsuccessful of last year, so that the proportion of individuals who succeed to individuals who fail, is, of course, considerably larger than one to four. Of the 170 candidates admitted in November, 1855, 117 had put down their names for the examination of 1854, and 53 only had not been previously inscribed. Of the 117 who put down their names, 19 had withdrawn without being examined at all, 71 had been rejected on the preliminary examination, 27 had been unsuccessful at that of the second degree; 98 of the 170 came up for the second time to the examination.

valuable qualities as readiness and power of expression; but an examination solely oral appears to us an uncertain test of depth or accuracy of knowledge; and however impartial or practiced an examiner may be, it is impossible that questions put orally can present exactly the same amount of difficulty, and so be equally fair, to the several competitors.

At the same time, although in all great competing examinations the chief part of the work (in our opinion) should be *written*, the constant oral cross-questioning of the minor examinations at the Polytechnic, appeared to be one of the most stimulating and effective parts of their system.

10. A more serious objection than any we have named lies against the exclusive use of mathematical and scientific training, to the neglect of all other, as almost the only instrument of education. The spirit of the school, as shown especially by its entrance examinations, is opposed to any literary study. This is a peculiar evil in forming characters for a liberal profession like the army. Such a plan may indeed produce striking results, if the sole object is to create distinguished mathematicians, though even then the acuteness in one direction is often accompanied by an unbalanced and extravagant judgment in another. But a great school should form the whole and not merely a part of the man; and as doing this, as strengthening the whole mind, instead of forcing on one or two of its faculties—as giving, in a word, what is justly called a *liberal* education—we are persuaded that the system of cultivating the taste for historical and other similar studies, as well as for mere science, is based on a sounder principle than that which has produced the brilliant results of the Polytechnic.

11. It may be added, in connection with the above remark, that as the entrance examination at the Polytechnic influences extensively the teaching of the great French schools, and is itself almost solely mathematical, it tends to diffuse a narrow and exclusive pursuit of science, which is very alien from the spirit of English teaching.

12. We may sum up our remarks on the Polytechnic School thus:—

Regarded simply as a great Mathematical and Scientific School, its results in producing eminent men of science have been extraordinary. It has been the great (and a truly great) Mathematical University of France.

Regarded again as a Preparatory School for the public works, it has given a very high scientific education to civil engineers, whose scientific education in other countries (and amongst ourselves) is believed to be much slighter and more accidental.

Regarded as a school for the scientific corps of the army, its peculiar mode of uniting in one course of competition candidates for civil and military services, has probably raised scientific thought to a higher point in the French than in any other army.

Regarded as a system of teaching, the method it pursues in developing the talents of its pupils appears to us the best we have ever studied.

It is in its studies and some of its main principles that the example of the Polytechnic School may be of most value. In forming or improving any military school, we can not shut our eyes to the successful working at the Polytechnic of the principle, which it was the first of all schools to initiate, the making great public prizes the reward and stimulus of the pupil's exertions. We may observe how the state has here encouraged talent by bestowing so largely assistance upon all successful, but poor pupils, during their school career. We may derive some lessons from its method of teaching, though the attempt to imitate it might be unwise. Meanwhile, without emulating the long established scientific prestige of the Polytechnic, we have probably amongst ourselves abundant materials for a military scientific education, at least as sound as that given at this great School.

NOTE.

In addition to the Schools of Application for Artillery and Engineers at Metz, and of Infantry and Cavalry at St. Cyr, of which a pretty full account will be given, the following Public Services are supplied by the Polytechnic School.

GUNPOWDER AND SALTPETRE.—(*Poudres et Salpêtres.*)

In France the manufacture of gunpowder is solely in the hands of the Government. The pupils of the Polytechnic who enter the gunpowder and saltpetre service, are sent in succession to different powder-mills and saltpetre refineries, so as to gain a thorough acquaintance with all the details of the manufacture.

On first entering the service they are named *élèves des poudres*. They afterwards rise successively to the rank of assistant-commissary, commissary of the third, of the second, and of the first class.

NAVY.—(*Marine.*)

A small number of the pupils of the Polytechnic enter the Navy. They receive the rank of *élève de première classe*, from the date of their admission.

They are sent to the ports to serve afloat. After two years' service they may be promoted to the rank of *enseigne de vaisseau*, on passing the necessary examinations, on the same terms precisely as the *élèves de première classe* of the Naval School.

MARINE ARTILLERY.—(*Artillerie de la Marine.*)

The French marine artillery differs from the English corps of the same name, in not serving afloat. Its duties are confined to the ports and to the colonies. It is governed by the same rules and ordinances as the artillery of the army.

The foundries of La Villeneuve, Rochefort, Ruelle, Névers, and Saint Gervais are under its direction.

The officers of the marine artillery are liable to be sent on board ship to study naval gunnery, so as to be in a position to report upon alterations or improvements in this science.

NAVAL ARCHITECTS.—(*Génie Maritime.*)

The naval architects are charged with the construction and repair of vessels of war, and with the manufacture of all the machinery required in the ports and dockyards. The factories of Indret and La Chaussade are under their direction.

The pupils of the Polytechnic enter the corps of naval architects with the rank of *élève du Génie Maritime*. They are sent to the School of Application of Naval Architects at L'Orient. After two years' instruction they undergo an examination, and, if successful, they are promoted to the rank of sub-architect of the third class, so far as vacancies admit. They may be advanced to the second class after a service of two years.

HYDROGRAPHERS.—(*Ingénieurs Hydrographes.*)

The hydrographers are stationed at Paris. They are sent to the coast to make surveys, and the time so spent reckons as a campaign in determining their pension. On their return to Paris they are employed in the construction of maps and charts.

The hydrographers have the same rank and advantage as the naval architects.

On leaving the Polytechnic, the pupils enter the corps of hydrographers with the rank of *élève hydrographe*. After two years' service, and one season employed on the coast, they become sub-hydrographers without further examination.

ROADS AND BRIDGES.—GOVERNMENT CIVIL ENGINEERS.—(*Ponts et Chaussées.*)

The Polytechnic furnishes exclusively the pupils for the Government Civil Engineer Corps. On leaving the Polytechnic, the pupils enter the School of Application in Paris. The course of instruction here extends over a period of three years. It commences each year on the first of November, and lasts till the 1st of April. After the final examination, the pupils are arranged according to the results of the examination and the amount of work performed.

The pupils enter the college with the rank of *élève de troisième classe.* They rise successively to the second and to the first class, on making the requisite progress in their studies.

From the 1st of May to the 1st of November the *élèves* of the second and the third class are sent on duty into the provinces. The *élèves* of the first class who have completed their three years' course of instruction, are employed in the duties of ordinary engineers, or are detached on special missions. In about three years after quitting the college, they may be appointed ordinary engineers of the second class.

The engineers of the *Ponts et Chaussées* prepare the projects and plans, and direct the execution of the works for the construction, preservation, and repair of high roads, and of the bridges and other structures connected with these roads, with navigable rivers, canals, seaports, lighthouses, &c. They are charged with the superintendence of railways, of works for draining marshes, and operations affecting water-courses; they report upon applications to erect factories driven by water. Under certain circumstances, they share with the Mining Engineers the duty of inspecting steam-engines.

Permission is not unfrequently granted to the engineers of the *Ponts et Chaussées* to accept private employment. They receive leave of absence for a certain time, retaining their rank and place in their corps, but without pay.

MINING ENGINEERS.—(*Mines.*)

The Mining School of Application is organized almost exactly on the same plan as that of the *Ponts et Chaussées:* like the latter, it is in Paris.

The course of instruction, which lasts three years, consists of lectures, drawing, chemical manipulation and analysis, visits to manufactories, geological excursions, and the preparation of projects for mines and machines. Journeys are made by the pupils, during the second half of the last two years of the course, into the mineral districts of France or foreign countries for the purpose of studying the practical details of mining. These journeys last one hundred days at least. The pupils are required to examine carefully the railroads and the geological features of the countries they pass through, and to keep a journal of facts and observations. In the final examination, marks are given for every part of their work.

The mining engineers, when stationed in the departments, are charged to see that the laws and ordinances relating to mines, quarries, and factories are properly observed, and to encourage, either directly or by their advice, the extension of all branches of industry connected with the extraction and treatment of minerals.

One of their principal duties is the superintendence of mines and quarries, in the three-fold regard of safety of the workmen, preservation of the soil, and economical extraction of the minerals.

They exercise a special control over all machines designed for the production of steam, and over railways, as far as regards the metal and fuel.

The instructors in the School of Application in Paris, and in the School of Mines at St. Etienne, are exclusively taken from the members of the corps.

Like the engineers of the *Ponts et Chaussées*, the mining engineers obtain permission to undertake private employment.

TOBACCO DEPARTMENT.—(*Administration des Tabacs.*)

The pupils who enter the tobacco service, commence, on quitting the Polytechnic, with the rank of *élève de 2e classe.* They study, in the manufactory at

Paris, chemistry, physics, and mechanics, as applied to the preparation of tobacco. They make themselves acquainted at the same time with the details of the manufacture and with the accounts and correspondence.

They are generally promoted to the rank of *élève de 1re classe* in two years. They rise afterwards successively to the rank of sub-inspector, inspector, and director.

After completing their instruction at the manufactory of Paris, the *élèves* are sent to tobacco manufactories in other parts of France.

Promotion in the tobacco service does not follow altogether by seniority. Knowledge of the manufacture and attention to their duties are much considered, as the interests of the treasury are involved in the good management of the service.

TELEGRAPHS.—(*Lignes Télégraphiques.*)

On entering the telegraphic service the pupils of the Polytechnic receive the rank of *élève inspecteur*.

They pass the first year at the central office. During the six winter months they study, under two professors, the composition of signals, and the regulations which insure their correctness and dispatch, the working of telegraphs and the manner of repairing them, the theory of the mode of tracing lines and of determining the height of the towers, electro-magnetism and its application to the electic telegraph. During the summer months they make tours of inspection. They assist in the execution of works, and practice leveling and the laying down of lines.

At the end of the year the *élèves inspecteurs* undergo an examination, and, if there are vacancies, are appointed provisional inspectors. After a year in this rank they may be appointed inspectors either in France or Algeria.

Each inspector has charge of a district containing from twelve to fifteen stations. He is obliged to make a tour of inspection once a month of at least ten days' duration.

After a certain number of years' service the inspector rises to the rank of director. Besides their other duties, the directors exercise a general superintendence over the inspectors.

PROGRAMMES OF THE PRINCIPAL COURSES OF INSTRUCTION

OF THE IMPERIAL POLYTECHNIC SCHOOL DURING THE TWO YEARS OF STUDY.

I. ANALYSIS.—*FIRST YEAR.*

DIFFERENTIAL CALCULUS.

LESSONS 1—9. *Derivatives and Differentials of Functions of a Single Variable.*

INDICATION of the original problems which led geometers to the discovery of the infinitesimal calculus.

Use of infinitesimals; condition, subject to which, two infinitely small quantities may be substituted for one another. Indication in simple cases of the advantage of such substitution.

On the different orders of infinitely small quantities. Infinitely small quantities of a certain order may be neglected in respect of those of an inferior order. The infinitely small increment of a function is in general of the same order as the corresponding increment of the variable, that is to say, their ratio has a finite limit.

Definitions of the derivative and differential of a function of a single variable. Tangents and normals to plane curves, whose equation in linear or polar co-ordinates is given.

A function is increasing or decreasing, according as its derivative is positive or negative. If the derivative is zero for all values of the variable, the function is constant. Concavity and convexity of curves; points of inflection.

Principle of function of functions. Differentiation of inverse functions.

Differentials of the sums, products, quotients, and powers of functions, whose differentials are known. General theorem for the differentiation of functions composed of several functions.

Differentials of exponential and logarithmic functions.

Differentials of direct and inverse circular functions.

Differentiation of implicit functions.

Tangents to curves of double curvature. Normal plane.

Differential of the area and arc of a plane curve, in terms of rectilinear and polar co-ordinates.

Differential of the arc of a curve of double curvature.

Applications to the cycloid, the spiral of Archimedes, the logarithmic spiral, the curve whose normal, sub-normal, or tangent, is constant; the curve whose normal passes through a fixed point; the curve whose arc is proportional to the angle which it subtends at a given point.

Derivatives and differentials of different orders of functions of one variable. Notation adopted.

Remarks upon the singular points of plane curves.

LESSONS—10—13. *Derivatives and Differentials of Functions of Several Variables.*

Partial derivatives and differentials of functions of several variables. The order in which two or any number of differentiations is effected does not influence the result.

Total differentials. Symbolical formula for representing the total differential of the n^{th} order of a function of several independent variables.

Total differentials of different orders of a function; several dependent varia-

bles. Case where these variables are linear functions of the independent variables.

The infinitesimal increment of a function of several variables may in general be regarded as a linear function of the increments assigned to the variables. Exceptional cases.

Tangent and normal planes to curved surfaces.

LESSONS 14—16. *Analytical Applications of the Differential Calculus.*

Development of $F(x+h,)$ according to ascending powers of h. Limits within which the remainder is confined on stopping at any assigned power of h.

Development of $F(x,)$ according to powers of x or $x-a$; a being a quantity arbitrarily assumed. Application to the functions $\sin(x,)$ $\cos x$, a^x, $(1+x^m)$ and $\log.(1+x.)$ Numerical applications. Representation of $\cos x$ and $\sin x$ by imaginary exponential quantities.

Developments of $\cos^m x$ and $\sin^m x$ in terms of sines and curves of multiples of x.

Development of $F(x+h, y+k,)$ according to powers of h and k. Development of $F(x, y)$ according to powers of x and y. Expression for the remainder. Theorem on homogeneous functions.

Maxima and minima of functions of a single variable; of functions of several variables, whether independent or connected by given equations. How to discriminate between maxima and minima values in the case of one and two independent variables.

True values of functions, which upon a particular supposition assume one or another of the forms

$$\frac{0}{0},\ \frac{\infty}{\infty},\ \infty+0,\ 0^0,\ 1^\infty$$

LESSONS 19—23. *Geometrical Applications. Curvature of Plane Curves.*

Definition of the curvature of a plane curve at any point. Circle of curvature. Center of curvature. This center is the point where two infinitely near normals meet.

Radius of curvature with rectilinear and polar co-ordinates. Change of the independent variable.

Contacts of different orders of plane curves. Osculating curves of a given kind. Osculating straight line. Osculating circle. It is identical with the circle of curvature.

Application of the method of infinitesimals to the determination of the radius of curvature of certain curves geometrically defined. Ellipse, cycloid, epicycloid, &c.

Evolutes of plane curves. Value of the arc of the evolute. Equation to the involute of a curve. Application to the circle. Evolutes considered as envelops. On envelops in general. Application to caustics.

LESSONS 14—17. *Geometrical Applications continued. Curvature of Lines of Double Curvature and of Surfaces.*

Osculating plane of a curve of double curvature. It may be considered as passing through three points infinitely near to one another, or as drawn through a tangent parallel to the tangent infinitely near to the former. Center and radius of curvature of a curve of double curvature. Osculating circle. Application to the helix.

Radii of curvature of normal sections of a surface. Maximum and minimum radii. Relations between these and that of any section, normal or oblique.

Use of the indicatrix for the demonstration of the preceding results Conjugate tangents. Definition of the lines of curvature. Lines of curvature of certain simple surfaces. Surface of revolution. Developable surfaces. Differential equation of lines of curvature in general.

LESSON 28. *Cylindrical, Conical, Conoidal surfaces, and Surfaces of Revolution.*

Equations of these surfaces in finite terms. Differential equations of the same deduced from their characteristic geometrical properties.

INTEGRAL CALCULUS.

LESSONS 29—34. *Integration of Functions of a Single Variable.*

Object of the integral calculus. There always exists a function which has a given function for its derivative.

Indefinite integrals. Definite integrals. Notation. Integration by separation, by substitution, by parts.

Integration of rational differentials, integer or fractional, in the several cases which may present themselves. Integration of the algebraical differentials, which contain a radical of the second degree of the form $\sqrt{c+bx+cx^2}$. Different transformations which render the differential rational. Reduction of the radical to one of the forms

$$\sqrt{x^2+x^2},\ \sqrt{a^2-x^2},\ \sqrt{x^2-a^2}.$$

Integration of the algebraical differentials which contain two radicals of the form

$$\sqrt{a+x},\ \sqrt{b+x},$$

or any number of monomials affected with fractional indices. Application to the expressions

$$\frac{x^m dx}{\sqrt{1-x^2}},\ \frac{dx}{x^m\sqrt{1-x^2}},\ \frac{x^m dx}{\sqrt{ax-x}}$$

Integration of the differentials

$$\mathrm{F}(\log x)\frac{dx}{x},\ \mathrm{F}\sin^{-1}x\frac{dx}{\sqrt{1-x^2}},\ x(\log x^m)\,dx,\ x^m e^{ax}\,dx,\ (\sin^{-1}x^m)\,dx.$$

Integration of the differentials $e^{ax}\sin bx dx$ and $e^{ax}\cos bx dx$.

Integration of $(\sin x^m.)(\cos x^n)\,dx$.

Integration by series. Application to the expression

$$\frac{dx}{\sqrt{ax-x^2}\ \sqrt{1-bx}}.$$

Application of integration by series to the development of functions, the development of whose derivatives is given; $\tan^{-1}x$, $\sin^{-1}x$, $\log(1+x)$.

LESSONS 35—38. *Geometrical Applications.*

Quadrature of certain curves. Circle, hyperbola, cycloid, logarithmic spiral, &c.

Rectification of curves by rectilinear or polar co-ordinates. Examples. Numerical applications.

Cubic content of solids of revolution. Quadrature of their surfaces.

Cubic content of solids in general, with rectilinear or polar co-ordinates. Numerical applications.

Quadrature of any curved surfaces expressed by rectangular co-ordinates. Application to the sphere.

LESSONS 39—42. *Mechanical Applications.*

General formula for the determination of the center of gravity of solids, curved or plane surfaces, and arcs of curves. Various applications.

Guldin's theorem.

Volume of the truncated cylinder.

General formula which represent the components of the attraction of a body upon a material point, upon the supposition that the action upon each element varies inversely as the square of the distance. Attraction of a spherical shell on an external or internal point.

Definition of moments of inertia. How to calculate the moment of inertia of a body in relation to a straight line, when the moment in relation to a parallel straight line is known. How to represent the moments of inertia of a body relative to the straight lines which pass through a given point by means of the radii vectores of an ellipsoid. What is meant by the *principal axes of inertia.*

Determination of the principal moments of inertia of certain homogeneous bodies, sphere, ellipsoid, prism, &c.

LESSONS 43—45. *Calculus of Differences.*

Calculation of differences of different orders of a function of one variable by means of values of the function corresponding to equidistant values of the variable.

Expression for any one of the values of the function by means of the first, and its differences. Numerical applications; construction of tables representing a function whose differences beyond a certain order may be neglected. Application to the theory of interpolation. Formulæ for approximation by quadratures. Numerical exercises relative to the area of equilateral hyperbola or the calculation of a logarithm.

LESSONS 46—48. *Revision.*

General reflections on the subjects contained in the preceding course.

ANALYSIS.—*SECOND YEAR.*

CONTINUATION OF THE INTEGRAL CALCULUS.

LESSONS 1—2. *Definite Integrals.*

Differentiation of a definite integral with respect to a parameter in it, which is made to vary. Geometrical demostration of the formula. Integration under the sign of integration. Application to the determination of certain definite integrals.

Determination of the integrals $\int \frac{\sin ax}{x}\,dx$, and $\int \frac{\cos bx \sin ax}{x}\,dx$, between the limits o and x. Remarkable discontinuity which these integrals present.

Determination of $\int e^{-x^2}\,dx$ and $\int e^{-x^2} \cos mx dx$ between the limits 0 and ∞.

LESSONS 3. *Integration of Differentials containing several Variables.*

Condition that an expression of the form $M\,dx + N\,dy$ in which M and N are given functions of x and y may be an exact differential of two independent variables x and y. When this condition is satisfied, to find the function.

Extension of this theory to the case of three variables.

LESSONS 4—6. *Integration of Differential Equations of the First Order.*

Differential equations of the first order with two variables. Problem in geometry to which these equations correspond. What is meant by their integral. This integral always exists, and its expression contains an arbitrary constant.

Integration of the equation $M\,dx + N\,dy = 0$ when its first member is an exact differential. Whatever the functions M and N may be there always exists a factor μ, such that $\mu\,(M\,dx + N\,dy)$ is an exact differential.

Integration of homogeneous equations. Their general integral represents a system of similar curves. The equation $(a + b\,x + c\,y)\,dx + (a' + b'\,x + c'\,y)\,dy = c$, may be rendered homogeneous. Particular case where the method fails. How the integration may be effected in such case.

Integration of the linear equation of the first order $\frac{dy}{dx} + P\,y = Q$, where P and Q denote functions of x. Examples.

Remarks on the integration of equations of the first order which contain a higher power than the first of $\frac{dy}{dx}$. Case in which it may be resolved in respect of $\frac{dy}{dx}$. Case in which it may be resolved in respect of x or y.

Integrations of the equation $y = x\frac{dy}{dx} + \phi\left(\frac{dy}{dx}\right)$. Its general integral represents a system of straight lines. A particular solution represents the envelop of this system.

Solution of various problems in geometry which lead to differential equations of the first order.

LESSONS 7—8. *Integration of Differential Equations of Orders superior to the First.*

The general integral of an equation of the m order contains m arbitrary constants.

(*The demonstration is made to depend on the consideration of infinitely small quantities.*)

Integration of the equation $\frac{d^m y}{dx^m} = \phi(x)$.

Integration of the equation $\frac{d^2 y}{dx^2} = \phi\left(y, \frac{dy}{dx}\right)$.

How this is reduced to an equation of the first order. Solution of various problems in geometry which conduct to differential equations of the second order.

LESSONS 9—10. *On Linear Equations.*

When a linear equation of the m^{th} order contains no term independent of the unknown function and its derivatives, the sum of any number whatever of

particular integrals multiplied by arbitrary constants is also an integral. From this the conclusion is drawn that the general integral of this equation is deducible from the knowledge of m particular integrals.

Application to linear equations with constant co-efficients. Their integration is made to depend on the resolution of an algebraical equation. Case where this equation has imaginary roots. Case where it has equal roots. The general integral of a linear equation of any order, which contains a term independent of the function, may be reduced by the aid of quadratures to the integration of the same equation with this term omitted.

LESSON 11. *Simultaneous Equations.*

General considerations on the integration of simultaneous equations. It may be made to depend on the integrations of a single differential equation. Integration of a system of two simultaneous linear equations of the first order.

LESSON 12. *Integrations of Equations by Series.*

Development of the unknown function of the variable x according to the powers of $x-a$. In certain cases only a particular integral is obtained. If the equation is linear, the general integral may be deduced from it by the variation of constants.

LESSONS 13—16. *Partial Differential Equations.*

Elimination of the arbitrary functions which enter into an equation by means of partial derivatives. Integration of an equation of partial differences with two independent variables, in the case where it is linear in respect to the derivatives of the unknown function. The general integral contains an arbitrary function.

Indication of the geometrical problem, of which the partial differential equation expresses analytically the enunciation. Integration of the partial differential equations to cylindrical, conical, conoidal surfaces of revolution. Determination of the arbitrary functions.

Integration of the equation $\frac{d^2u}{dy^2}=a^2\frac{d^2u}{dx^2}$. The general integral contains two arbitrary functions. Determination of these functions.

LESSONS 17—23. *Applications to Mechanics.*

Equation to the catenary.

Vertical motion of a heavy particle, taking into account the variation of gravity according to the distance from the center of the earth. Vertical motion of a heavy point in a resisting medium, the resistance being supposed proportional to the square of the velocity.

Motion of a heavy point compelled to remain in a circle or cycloid. Simple pendulum. Indication of the analytical problem to which we are led in investigating the motion of a free point.

Motion of projectiles in a vacuum. Calculation of the longitudinal and transversal vibrations of cords. Longitudinal vibrations of elastic rods. Vibration of gases in cylindical tubes.

LESSONS 24—26. *Applications to Astronomy.*

Calculation of the force which attracts the planets, deduced from Kepler's laws. Numerical data of the question.

Calculation of the relative motion of two points attracting one another, according to the inverse square of the distance.

Determination of the masses of the earth and of the planets accompanied by satellites. Numerical applications.

LESSONS 27—30.

Elements of the calculus of probabilities and social arithmetic.

General principles of the calculus of chances. Simple probability, compound probability, partial probability, total probability. Repeated trials. Enunciation of Bernouilli's theorem (without proof.)

Mathematical expectation. Applications to various cases, and especially to lotteries.

Tables of population and mortality. Mean life annuities, life interests, assurances, &c.

LESSONS 31—32. *Revision.*

General reflections on the subjects comprised in the course.

II. DESCRIPTIVE GEOMETRY AND STEREOTOMY.

General Arrangements.

The pupils take in the lecture-room notes and sketches upon sheets, which are presented to the professor and the "répétiteurs" at each interrogation. The care with which these notes are taken is determined by "marks," of which account is taken in arranging the pupils in order of merit.

The plans are made according to programmes, of which the conditions are different for different pupils. The drawings are in general accompanied with decimal scales, expressing a simple ratio to the meter. They carry inscriptions written conformably to the admitted models, and are, when necessary, accompanied with verbal descriptions.

In the graphic exercises of the first part of the course, the principal object is to familiarize the pupils with the different kinds of geometrical drawing, such as elevations and shaded sections, oblique projections and various kinds of perspective. The pupils are also accustomed to different constructions useful in stereotomy.

The subjects for graphic exercises in stereotomy are taken from roofs, vaults, and staircases. Skew and oblique arches are the subject of detailed plans.

FIRST YEAR.

DESCRIPTIVE GEOMETRY.—GEOMETRICAL DRAWING.

LESSONS 1—8 *Revision and Completion of the Subjects of Descriptive Geometry comprised in the Programme for Admission into the School.*

Object of geometrical drawing. Methods of projection. Representation of points, lines, planes, cones, cylinders, and surfaces of revolution. Construction of tangent planes to surfaces, of curves, of intersection of surfaces, of their tangents and their assymptotes.

Osculating plane of a curve of double curvature. A curve in general cuts its osculating plane.

When the generating line of a cylinder or a cone becomes a tangent to the directrix, the cylinder or cone in general has an edge of regression along this

generating line. The osculating plane of the directrix at the point of contact touches the surface along this edge.

Projections of curves of double curvature; infinite branches and their assymptotes, inflections, nodes, cusps, &c.

Change of planes of projection.

Reduction of scale; transposition.

Advantage and employment of curves of error; their irrelevant solutions.

Lessons 4—6. *Modes of Representation for the Complete Definition of Objects.*

Pepresentation by plans, sections, and elevation.

Projection by the method of contours. Representation of a point, a line, and a plane; questions relative to the straight line and plane. Representation of cones and cylinders; tangent planes to these surfaces.

Lessons 7—11. *Modes of Representation which are not enough in themselves to define objects completely*

Isometrical and other kinds of perspective.

Oblique projections.

Conical perspective: vanishing points; scales of perspective; method of squares; perspective of curved lines; diverse applications. Choice of the point of sight. Rules for putting an elevation in perspective. Rule for determining the point of sight of a given picture, and for passing from the perspective to the plan as far as that is possible. Perspective of reflected images. Notions on panoramas.

Lessons 12—13. *Representations with Shadows.*

General observations on envelops and characteristics.

A developable surface is the envolop of the position of a movable plane; it is composed of two sheets which meet. It may be considered as generated by a straight line, which moves so as to remain always a tangent to a fixed curve.

Theory of shade and shadow, of the penumbra, of the brilliant point, of curves of equal intensity, of bright and dark edges.

Atmospheric light: direction of the principal atmospheric ray. Notions on the degradation of tints; construction of curves of equal tint.

Influence of light reflected by neighboring bodies.

Received convention in geometrical drawing on the direction of the luminous ray, &c.

Perspective of shadows.

Lessons 14—15. *Construction of Lines of Shadows and of Perspective of Surfaces.*

Use of circumscribed cones and cylinders, and of the normal parallel to a given straight line.

General method of construction of lines of shadow and of perspective of surfaces by plane sections and auxiliary cylindrical or conical surfaces.

Construction of lines of shadow and perspective of a surface of revolution.

The curve of contact of a cone circumscribed about a surface of the second degree is a plane curve. Its plane is parallel to the diametral plane, conjugate to the diameter passing through the summit of the cone. The curve of contact of a cylinder circumscribed about a surface of the second degree is a plane

curve, and situated in the diametral plane conjugate to the diameter parallel to the axis of the cylinder.

The plane parallel sections of a surface of the second degree are similar curves. The locus of their centers is the diameter conjugate to that one of the secant planes which passes through the center of the surface.

General study of surfaces with reference to the geometrical constructions to which their use gives rise.

LESSON 16. *Complementary Notions on Developable Surfaces.*

Development of a developable surface; construction of transformed curves and their tangents. Developable surface; an envelop of the osculating planes of a curve. The osculating plane of a curve at a given point may be constructed by considering it as the edge of regression of a developable surface; this construction presents some uncertainty in practice. Notions on the helix and the developable helicoid.

Approximate development of a segment of an undevelopable surface.

LESSONS 17—18. *Hyperbolic Paraboloid.*

Double mode of generation of the paraboloid by straight lines; plane-directers; tangent planes, vertex, axis, principal planes; representation of this surface. Construction of the tangent plane parallel to a given plane. Construction of plane sections and of curves of contact, of cones, and circumscribed cylinders.

Scalene paraboloid. Isoceles paraboloid.

Identity of the paraboloid with one of the five surfaces of the second degree studied in analytical geometry.

Re-statement without demonstration of the properties of this surface found by analysis, principally as regards its generation by the conic sections.

LESSONS 19—20. *General Properties of Warped or Ruled Surfaces.*

Principal modes of generation of warped surfaces. When two warped surfaces touch in three points of a common generatrix, they touch each other in every point of this straight line. Every plane passing through a generatrix touches the surface at one point in this line. The tangent plane at infinity is the plane-directer to all the paraboloids of "raccordement."

Construction of the tangent planes and curves of contact of circumscribed cones and cylinders. When two infinitely near generatrices of a warped surface are in the same plane, all the curves of contact of the circumscribed cones and cylinders pass through their point of concourse.

The normals to a warped surface along a generatrix form an isoceles paraboloid. The name of central point of a generatrix is given to the point where it is met by the straight line upon which is measured its shortest distance from the adjoining generatrix. The locus of these points forms the line of striction of the surface. The vertex of the normal paraboloid along a generating line is situated at the central point. If the point of contact of a plane touching a warped surface moves along a generatrix, beginning from the central point, the tangent of the angle which the tangent plane makes with its primitive position is proportional to the length described by the point of contact. The tangent

plane at the central point is perpendicular to the tangent plane at infinity upon the same generatrix. Construction of the line of striction by aid of this property.

LESSONS 21—22. *Ruled Surfaces with plane-directors Conoids.*

The plane-director of the surface is also so to all the paraboloids of "raccordement." Construction of the tangent planes and curves of contact of the circumscribed cones and cylinders.

The line of striction of the surface is its curve of contact with a circumscribed cylinder perpendicular to the director-plane. Determination of the nature of the plane sections.

The lines of striction of the scalene paraboloid are parabolas; those of the isosceles paraboloid are straight lines.

Construction of the tangent plane parallel to a given plane.

Conoid: discussion of the curves of contact of the circumscribed cones and cylinders.

Right conoid. Conoid whose intersection with a torus of the same height, whose axis is its rectilinear directrix, has for its projection upon the director-plane two arcs of Archimedes' spiral. Construction of the tangents to this curve of intersection.

LESSONS 23—25. *Ruled Surfaces which have not a Director-Plane. Hyperboloid. Surface of the "biais passe."*

Director-cone: its advantages for constructing the tangent plane parallel to a given plane, and for determining the nature of the plane sections. The tangent planes to the points of the surface, situated at infinity, are respectively parallel to the tangent plane of the director-cone. Developable surface which is the envelope of these tangent planes at infinity. Construction of a paraboloid of *raccordement* to a ruled surface defined by two directrices and a directrix cone.

Hyperboloid; double mode of generation by straight lines; center; asymptotic cone.

Scalene hyperboloid; hyperboloid of revolution. Identity of the hyperboloid with one of the five surfaces of the second degree studied in analytical geometry.

Re-statement without demonstration of the properties of this surface, found by analysis, principally as to what regards the axis, the vertices, the principal planes, and the generation by conic sections.

Hyperboloid of *raccordement* to a ruled surface along a generatrix; all their centers are in the same plane. Transformation of a hyperboloid of *raccordement*.

Surface of the *biais passé*. Construction of a hyperboloid of *raccordement*; its transformation into a paraboloid.

Construction of the tangent plane at a given point.

LESSONS 26—28. *Curvature of Surfaces. Lines of Curvature.*

Re-statement without proof of the formula of Euler given in the course of analysis.

There exists an infinity of surfaces of the second degree, which at one of their vertices osculate any surface whatever at a given point.

In the tangent plane, at a point of a surface, there exists a conic section, whose diameters are proportional to the square roots of the radii of curvature of the normal sections to which they are tangents. This curve is called the indicatrix. It is defined in form and position, but not in magnitude. The normal sections tangential to the axes of the indicatrix are called the principal sections.

The indicatrix an ellipse; convex surfaces; umbilici; line of spherical curvatures.

The indicatrix a hyperbola; surfaces with opposite curvatures.

The assymptotes of the indicatrix have a contact of the second order with the surface, and of the first order with the section of the surface by its tangent plane.

A ruled surface has contrary curvatures at every point. The second assymptotes of the indicatrices of all the points of the same generatrix form a hyperboloid, if the surface has not director-plane,—a paraboloid, if it have one.

Curvature of developable surfaces.

There exists upon every surface two systems of orthogonal lines, such that every straight line subject to move by gliding over either of them, and remaining normal to the surface, will engender a developable surface. These lines are called lines of curvature.

The two lines of curvature which cross at a point, are tangents to the principal sections of the surface at that point.

Remarks upon the lines of curvature of developable surfaces, and surfaces of revolution.

Determination of the radii of curvature, and assymptotes of the indicatrix at a point of a surface of revolution.

LESSONS 29—30. *Division of Curves of Apparent Contour, and of Separation of Light and Shadow into Real and Virtual Parts.*

When a cone is circumscribed about a surface, at any point whatever of the curve of contact, the tangent to this curve and the generatrix of the cone are parallel to two conjugate diameters of the indicatrix.

Surfaces, as they are considered in shadows, envelop opaque bodies, and the curve of contact of a circumscribed cone, only forms a separation of light and shadow, for a luminous point at the summit of the cone, when the generatrices of this cone are exterior. This line is thus sometimes real and sometimes virtual.

Upon a convex surface, the curve of separation of light and shade is either all real or all virtual. Upon a surface with contrary curvatures, this curve presents generally a succession of real and virtual parts: the curve of shadow cast from the surface upon itself presents a like succession. These curves meet tangentially, and the transition from the real to the virtual parts upon one and the other, take place at their points of contact in such a way that the real part of the curve of shadow continues the real part of the curve of separation of light and shade. The circumscribed cones have edges of regression along the generatrices, which correspond to the points of transition.

The lines of visible contour present analogous circumstances.

General method of determining the position of the transition points. Special method for a surface of revolution.

LESSONS 31—34. *Ruled Helicoidal Surfaces.*

Surface of the thread of the triangular screw; generation, representation, sections by planes and conical cylinders.

Construction of the tangent plane at a given point, or parallel to a given plane. The axis is the line of striction.

Construction of lines of shadow and perspective: their infinite branches, their assymplotes. Determination of the osculating hyperboloid along a generatrix.

Representation and shading of the screw with a triangular thread and its nut.

Surface of the thread of the square screw; generation, sections by planes and conical cylinders; tangent planes; curve of contact of a circumscribed cone.

The curve of contact of a circumscribed cylinder is a helix whose *step* is half that of the surface. Determination of the osculating paraboloid. At any point whatever of the surface, the absolute lengths of the radii of curvature are equal.

Representation and shading of the screw with a square thread, and of its nut.

Observations on the general ruled helicoidal surface, and on the surface of intrados of the winding staircase.

LESSON 35. *Different Helicoidal Surfaces.*

Saint-Giles screw, worm-shaped screw and helicoidal surfaces to any generatrix. Every tangent to the meridian generatrix describes a screw surface with triangular thread, which is circumscribed about the surface, along a helix, and may be used to resolve the problems of tangent planes, circumscribed cylinders, &c.

Helicoid of the open screw, its generation, tangent planes.

LESSONS 36—37. *Topographical Surfaces.*

Approximate representation of a surface by the figured horizontal projections of a series of equidistant horizontal sections. This method of representation is especially adapted to topographical surfaces, that is to say, surfaces which a vertical line can only meet in one point.

Lines of greatest slope. Trace of a line of equal slope between two given points.

Intersection of a plane and a surface, of two surfaces, of a straight line and a surface.

Tangent planes, cones, and cylinders circumscribed about topographical surfaces.

Use of a topographical surface to replace a table of double-entry when the function of two variables, which it represents, is continuous. It is often possible, by a suitable anamorphosis, to make an advantageous transformation in the curves of level.

LESSON 38. *Revision.*

Review of the different methods of geometrical drawing. Advantages and disadvantages of each.

Comparison of the different kinds of surfaces, *résumé* of their general properties.

Object, method, and spirit of descriptive geometry.

SECOND YEAR.

STEREOTOMY.—WOOD-WORK.

LESSONS 1—4. *Generalities.*

Notions on the mode of action of forces in carpentry. Resistance of a piece of wood to a longitudinal effort and to a transversal effort. Distinction between resistance to flexure and resistance to rupture. Beams.

Advantages of the triangular system, St. Andrew's cross.

LESSONS 5—8. *Roofs.*

Ordinary composition of roofs.

Distribution of pressures in the different parts of a girded roof.

Design of the different parts of roofs, &c., &c.

LESSONS 9—10. *Staircases.*

MASONRY.

LESSONS 11—12. *Generalities.*

Notions on the settlement of vaulted roofs. Principal forms of vaults, *en berceau*, &c., &c.

Distribution of the pressures, &c.

Division of the intrados. Nature of the surfaces at the joints, &c., &c.

LESSONS 13—15. *Berceaux and descentes.*

LESSONS 16—22. *Skew Arches.*

Study of the general problem of skew arches.

First solution. Straight arches *en échelon*.

Second solution: Orthogonal *appareil*. True and principal properties of the orthogonal trajectories of the parallel sections of an elliptical or circular cylinder. Right conoid, having for directrices the axis of the circular cylinder and an orthogonal trajectory. The intersection of this conoid by a cylinder about the same axis is an orthogonal trajectory for a series of parallel sections.

Third solution: helicoidal. Determination of the angular elevation at which the surfaces of the beds become normal to the head planes; construction in the orthogonal and helicoidal *appareil* of the curves of junction upon the heads, and the angles which they form with the curves of intrados. Cutting of the stones in these different constructions. Broken helicoidal *appareil*, for very long skew arches.

Helicoidal *trompes* at the angles of straight arches; *voussures* or widenings, which it is necessary to substitute near the heads at the intrados of an arch with a considerable skew; case where the skew is not the same for the two heads. Orthogonal trajectories of the converging sections of a cylinder.

LESSONS 23—25. *Conical Intrados—Intrados of Revolution.*

Skew *trompe* in the angle. Suggestions on the general problem of conical skew vaulted roofs.

Spherical domes, &c.

LESSONS 26—27. *Intrados, a Ruled Surface.*

Winding staircases, &c., &c.

LESSON 28. *Helicoidal Intrados.*

Staircase on the Saint-Gilles screw.

LESSONS 29—31. *Composite Vaulted Roofs.*

Various descriptions of vaults.

Suggestions on vaulted roofs with polygonal edges and with ogival edges.

LESSON 32. *Revision.*

Spirit and method of stereotomy.

Degree of exactness necessary. Approximate solutions. Case where it is proper to employ calculation in aid of graphical constructions.

Review and comparison of different *appareils.*

MECHANICS AND MACHINES.

GENERAL ARRANGEMENTS.

The pupils execute during the two years of study:—

1. Various drawings or plans of models in relief, representing the essential and internal organs of machines, such as articulations of connecting rods, winch-handles and fly-wheels, grease-boxes, eccentrics worked by cams or circles giving motion to rods; the play of slides, &c.; cylinders of steam-engines, condenser, pistons, and various suckers; Archimedes' screw, and other parts of machines.

The sketches of the plan drawings are traced by hand and figured. The drawings in their finished state are washed and colored according to the table of conventional tints; they all carry a scale suitably divided.

2. A drawing of wheel-work by the method of development, and tracing the curves of teeth by arcs of circles from which they are developed. This drawing represents, of the natural size, or on any other scale of size considered suitable to show the nature of the partial actions only, a small number of teeth either in development or projection; the entire wheel-work is represented by the usual method of projection, where in drawings on a small scale the teeth are replaced by truncated pyramids with a trapezoidal base.

3. Finally, numerical exercises concerning the loss of work due to the prejudicial resistances in various machines, the gauging of holes, orifices, &c.

Models in relief, or drawings on a large scale, of the machines or elements of the machines mentioned in the course, assist in explaining the lessons. They are brought back, as often as found necessary, under the eyes of the students. When possible, lithographic sketches of the machines, or the elements of the machines, which ought to enter into the course, are distributed among the pupils.

The pupils, divided into sections, pay their first visit to the engine factories towards the end of their first year of study; they make one or more additional visits at the end of the second year.

FIRST YEAR.

PART I. KINEMATICS.—PRELIMINARY ELEMENTARY MOVEMENTS OF INVARIABLE POINTS AND SYSTEMS.

LESSONS 1—2.

Object of kinematics, under the geometrical and experimental point of view. Its principal divisions.

Re-statement of the notions relative to the motion of a point, its geometrical representation, and more especially the determination of its velocity.

Simultaneous Velocities of a Point and the Increments of its Velocities.

Ratio of the elementary displacement and the velocity of a point to the displacement, and velocity of its projection upon a straight line or plane. Use of infinitesimals to determine these ratios. Example:—Oscillatory motion of the projection upon a fixed axis of a point moving uniformly upon the circumference of a circle.

Analogous considerations for polar co-ordinates. Relations of the velocity of a point, of its velocity of revolution and its angular velocity about a fixed pole; of its velocity in the direction of the radius vector; of the velocity of increase of the area which this radius describes.

Simple Motions of Solids, or Rigid Systems.

1. Motion of rectilinear or curvilinear translation; simultaneous displacements, and velocities of its different points.

2. Motion of rotation about a fixed axis; relation of the velocities of different points to the angular velocity.

Geometrical notions and theorems relative to the *instantaneous center* of rotation of a body of invariable figure and movable in one plane, or to the *instantaneous axis* of rotation of a rigid system situated in space, and movable parallel to a fixed plane. Relation of the velocities of different points to their common angular velocity. Use of the instantaneous center of rotation for tracing tangents; examples—and amongst others—that of the plane curve described by a point in a straight line of given length, whose extremities slide upon two fixed lines. Rolling of a curve upon another fixed curve in a plane. Descartes' theorems upon the intersection of the normals at the successive points of contact: cycloids, epicycloids, involutes, and evolutes. Extension of the preceding motions to the instantaneous axis of rotation of a rigid system movable about a fixed point.

COMPOSITION OF MOTIONS.

LESSONS 3—6 *Composition of the Velocities of a Point.*

Polygon of velocities. Example of movements observed relatively to the earth. Particular cases; composition of velocities taken along three axes; composition of the velocity of a point round a fixed pole, and its velocity along the radius vector. Method of Roberval for tracing tangents.

Composition of the Simple Motions of a Solid System.

Composition of any number of translatory displacements of a solid. Composition of two rotations about two intersecting axes. Composition of any number of rotations about axes cutting one another at the same point; parallelopiped and polygon of rotations. Composition of two simultaneous rotations about parallel axes; case where the rotations are equal and of opposite kinds. Decomposition of a rotation about an axis into an equal rotation about any axis whatever parallel to the first, and a translation perpendicular to the direction of this axis. Direct and geometrical decomposition of the most general motions of a body into a rotation about, and a translation along, an axis called the *instantaneous axis*. Composition of any two motions whatever. Every movement of an invariable system is at each instant of time decomposable into three movements of rotation, and three movements of tranlation with respect to three axes, which are neither parallel nor lying in the same plane, but otherwise arbitrarily chosen.

Relative or Apparent Motions.

Relative motion of two points whose absolute motions are given graphically *à priori*. Trajectory of the relative motions, relative velocities, and displacements upon curves or upon the direction of the mutual distance of the two points; use of the parallelogram to determine its amount. Relative motion of a point in motion in respect of a body turning about a fixed axis; relative motion of two bodies which turn about parallel or converging axes, and in general of two rigid bodies or systems impelled by any motions whatever. How this problem is immediately reduced to that of the composition of given motions.

The most general continued motion of an invariable figure in a plane is an *epicycloidal* motion, in which the instantaneous center describes a curve fixed in relation to absolute space, and traces relatively to the proposed figure a movable curve, which is rigidly connected with that figure and draws it along with it in its motion of rolling upon the other fixed curve. Case of space or spherical figures.

ON THE ACCELERATED MOTION OF A POINT.

LESSONS 7—9. *Accelerated Rectilinear Motion.*

Re-statement of the motions acquired relatively to the acceleration in the variable rectilinear motion of a point. Brief indication of the solution of six problems arising out of the investigation of the laws of the motion in terms of the space, time, velocity, and accelerating force. For the most part these solutions may be brought to depend on exact or approximate quadratures. Numerical exercises.

Accelerated Curvilinear Motions.

Re-statement of the notions acquired relative to the composition of accelerating forces; the resulting acceleration, the normal and tangential acceleration animating a point in motion on a curve. The total acceleration of a point upon an axis or plane is the projection upon this axis or plane of the acceleration of the moving body in space. In uniform curvilinear motion the total or resultant acceleration becomes normal to the curve. Particular case of the circle; value of the normal acceleration in terms of the velocity of revolution or the angular

velocity of the radius vector. Case of any curve whatever; geometrical expression of the total or resultant acceleration.

Accelerated Compound and Relative Motions.

Geometrical investigation of the simple and compound accelerations arising out of the hypothesis in which the motion of any system of points whatever is referred to another system of invariable form, but also in motion, Geometrical and elementary explanations of the results obtained by means of the transformation of co-ordinates.

Examples or Exercises chosen from among the following Questions:—

Projection of circular and uniform motion upon a fixed straight line or plane; motion of a circle which rolls uniformly on a straight line; comparison of the motions of the planets relatively to each other, treating them as circular and uniform; comparison of the accelerating force on the moon with that of bodies which fall to the earth.

GEOMETRICAL THEORY AND APPLICATION OF MECHANISMS OR CONTRIVANCES FOR THE TRANSFORMATION OF MOTION.

Lessons 10—19.

Succinct notions on the classification of elementary motions and organs for transmission of motion in machines after Monge and Hachette, Lanz and Bétancourt.

The most essential details upon this subject are set forth in the following order, and made clear by outline drawings previously distributed among the pupils.

Organs fitted to regulate the direction of the circular or rectilinear motion of certain pieces.

Axle; trunnions, gudgeons; pivots and bearings; couplings of axes; adjustment of wheels and of their arms. Joints with hinges, &c.; sheaves and pulleys; chains, ropes, and straps; means of securing them to the necks. Grooves and tongue-pieces. Eyelet-holes sliding along rectilinear or curvilinear rods. Advantages and disadvantages of these different systems of guides under the point of view of accuracy.

Rapid indication of some of their applications to drawbridges and to the movable frames or wagons of saw-works and railways.

Transmission at a Distance of Rectilinear Motion in a determinate Direction and Ratio.

Inclined plane or wedge guiding a vertical rod. Wedge applied to presses. Rods, winch-handles, &c. Disposition of drums or pulleys in the same plane or in different planes; geometrical problem on this subject. Fixed and movable pulleys. Blocks to pulleys. Simple and differential wheel and axle moved by cords. Transmission through a liquid. Ratios of velocities in these different organs.

Direct Transformation of circular progressive motion into progressive and intermittent rectilinear motion.

Rod conducted between guides: 1°, by the simple contact of a wheel; 2°, by cross-straps or chains; 3°, by a projecting cam; 4°, by means of a helicoidal

groove set upon the cylindrical axis of the wheel. To-and-fro movement, and heart-shaped or continuous cam, waves, and eccentrics. Simple screw and nut. Left and right handed screws; differential screw of Prony, called the micrometric screw. Ratio of the velocities in these different organs.

The example of the cam and pile-driver will be particularly insisted upon; 1°, in the case where this cam and the extremity of the rod have any continuous form given by a simple geometrical drawing; 2°, in the case where this form is defined geometrically by the condition, that the velocity is to be transmitted in an invariable ratio, as takes place for cams in the form of epicycloids or involutes of circles.

Transformation of a circular progressive motion into another similar to the first.

1°, by contact of cylinders or cones, the two axes being situated in the same plane; 2°, by straps, cords, or endless chains, the axes being in the same situation; 3°, by cams, teeth, and grooves, at very slight intervals; 4°, by the Dutch or universal joint. Case, where the axes are not situated in the same plane; use of an intermediate axis with beveled wheels or a train of pulleys; idea of White or Hooke's joint in its improved form. Endless screw specially employed in the case of two axes at right angles to one another. Combinations or groupings of wheels. Idea of differential wheels. Relations of velocities in the most important of these systems of transmission.

Transformation of circular progressive Motion into rectilinear or alternating circular motion.

Ordinary circular eccentric. Eccentrics with closed waves or cams. Examples and graphical exercises in the class-rooms relative to the alternate action of the traveling frames of saw-mills, of the slides or entrance valves of steam-engines. Cams for working hammers and bellows.

Transformation of alternating circular motion into alternating rectilinear motion, or into intermittent and progressive circular motion.

Pump rods with or without circular sectors, &c. Examples taken from large exhausting pumps, fire-engines, and common pumps. Suggestions as to the best arrangement of the parts. Lagarousse's lever, &c. Application of the principle relative to the instantaneous center of rotation to give the relations of the velocities in certain simple cases.

Transformation of alternating circular or rectilinear motions into progressive circular motion.

The knife-grinder's treadle. System of great machines worked with connecting rods, fly-wheel, &c. Watt's parallelogram, and the simplest modifications of it for steamboats, for instance. The most favorable proportions for avoiding the deviation of piston-rods. Simplification of parts in the modern steam-engines of Maudsley, Cavé, &c. Variable ratios of the velocities.

Of organs for effecting a sudden change of motion.

Suspendors or moderators, &c. Dead wheels and pulleys, &c. Mechanisms for stretching cords or straps, and make them change pulleys during the motion. Brakes to windmills, carriages, &c., &c. Case where the axes are rendered

movable. Means for changing the directions and velocity of the motions. Coupled and alternate pulleys; alternate cones; castors moving by friction and rotation upon a plate or turning-cone; eccentric and orrery wheels. Means of changing the motion suddenly and by intervals; wheels with a detent pile-drivers; Dobo's escapement for diminishing the shock, &c.

Geometrical Drawing of Wheel-work.

General condition which the teeth of toothed wheels must satisfy. Consequence resulting from this for the determination of the form of the teeth of one of two wheels, when the form of the teeth of the other wheel is given.

Cylindrical action of toothed wheels or toothed wheels with parallel axes. External engagement of the teeth; internal engagement. Particular systems of toothed wheels; lantern wheels, flange wheels, involutes of circles. Reciprocity of action; case where the action can not be rendered reciprocal. Pothook action. Details as to the form and dimensions given in practice to the teeth and the spaces which separate them.

Conical action of toothed wheels, or toothed wheels with converging axes. Practical approximate method of reducing the construction of a conical to that of a cylindrical engagement of toothed wheels.

Means of observation and apparatus proper for discovering experimentally the laws of any given movement.

Simple methods practiced by Galileo and Coulomb in their experiments relative to the inclined plane and the motion of bodies sliding down it. Various means of observing and discovering the law of the translatory and rotatory motion of a body according as the motion is slow or rapid. Determination of the angular velocity, &c. The counter in machines. Apparatus of Mattei and Grobert for assigning the initial velocity of projectiles (musket balls.) Colonel Beaufoy's pendulum apparatus. Chronometrical apparatus for continuous indications by means of a pencil. Eytelwein's apparatus with bands, and its simplest modifications. Apparatus with cylinders,or revolving disks. Use of the tuning-fork for measuring with precision very small fractions of time.

(The principal sorts of the apparatus above described are made to act under the eyes of the pupils.)

PART II.—EQUILIBRIUM OF FORCES APPLIED TO MATERIAL SYSTEMS.

Lesson 21.

Résumé of the notions acquired upon the subject of forces, and their effects on material points.

Principle of inertia, notion of force, of its direction, of its intensity. Principle of the equality of action and reaction. What is meant by the force of inertia? Principle of the independence and composition of the effects of forces. Forces proportional to the acceleration which they produce on the same body. Composition of forces. Relation between the accelerating force, the pressure, and the mass. Definition of the work done by a force. The work done by the resultant is equal to the sum of the works done by the components. Moment of a force in relation to an axis deduced from the consideration of the work of the force applied to a point turning about a fixed line. The moment of the re-

sultant of several forces applied to a point is equal to the sum of the moments of the components. Corresponding propositions of geometry.

LESSONS 22—25.

Succinct Notions upon the Constitution of Solid Bodies.

Every body or system of bodies may be regarded as a combination of material points isolated or at a distance, subject to equal and opposite mutual actions. Interior and exterior forces. Example of two molecules subject to their reciprocal actions alternately, attractive and repulsive, when the forces applied draw them out of their position of natural equilibrium. Different degrees of natural solidity, stability, or elasticity; they can only be appreciated by experience.

Equilibrium of any Systems whatever of Material Points.

General theorem of the virtual work of forces applied to any system whatever of material points. It is applicable to every finite portion of the system, provided regard be had to the actions exercised by the molecules exterior to the part under consideration. Determination of the sum of the virtual works of the equal and reciprocal actions of two material points. Demonstration of the six general equations of equilibrium of any system whatever. They comprise implicitly *every* equation deduced from a virtual movement compatible with the pre-supposed solidification of the system.

Theorem on the virtual work in the case of systems where one supposes ideal connections, such as the invariability of the distance of certain points of the system from one another, and the condition that certain of them are to remain upon curves either fixed or moving without friction.

Equilibrium of Solid Bodies.

The six general equations of equilibrium are sufficient as conditions of the equilibrium of a solid body. Theory of moments and couples.

APPLICATIONS.

LESSONS 26—29. *Equilibrium of Heavy Systems.*

Recapitulation of some indispensable notions for the experimental determination of the center of gravity of solids when the law of their densities is unknown. Re-statement of the theorem relative to the work done by gravity upon a system of bodies connected or otherwise. In machines supposed without friction submitted, with the exception of their supports, to the action of gravity alone, the positions of stable or unstable equilibrium correspond to the highest or lowest points of the curve which would be described by the center of gravity of the system when made to move. Influence of defect of centering in its wheels, upon the equilibrium of a machine. Case where the center of gravity always remaining at the same height the equilibrium is neutral. Examples relative to the most simple drawbridges, &c.

Equilibrium of Jointed Systems.

Equilibrium of the funicular polygon deduced from direct geometrical considerations: Varignon's theorem giving the law of the tensions by another

polygon whose sides are parallel and proportional to the forces acting upon the vertices of the funicular polygon. Case of suspension bridges; investigation of the curve which defines the boundary of the suspension chain; tensions at the extremities.

Equilibrium of systems of jointed rigid bodies without friction. Determination of the pressure upon the supports and the mutual actions at the joints.

Equilibrium and stability of solid bodies submitted to the action of stretching or compressing forces.

Permanent resistance and limiting resistance of prisms to longitudinal extension and compression. Equilibrium and stability of a heavy solid placed upon a horizontal plane and submitted to the action of forces which tend to overset it. Resultant pressure and mean pressure; hypothetical distribution of the elements of the pressure on the base of support. Conditions of stability, regard being had to the limit of resistance of solid materials, co-efficient of stability deduced from it.

PART III.—ON THE WORK DONE BY FORCES IN MACHINES.

Lessons 30—39. *General Notions.*

Principle of work in the motion of a material point. Extension of this principle to the case of any material system whatever in motion. Considerations relative to mechanical work in various operations, such as the lifting of weights, sawing, planing, &c. It is the true measure of the productive activity of forces in industrial works. It may always be calculated either rigorously or approximately when the mathematical or experimental law which connects the force with the spaces described is given. Uniform work, periodical work, mean work, for the unit of time. Horse-power unit. Examples and various exercises, such as the calculation of the work corresponding to the elasticity of gases on the hypothesis of Mariotte's law, the elongation of a metallic prism, &c.

Dynamometrical Apparatus.

Dynamometer of traction by a band or rotating disc or register. Dynamometer of rotation with simple spring, with band or register. Dynamometer of rotation with multiple springs and with register for the axles of powerful machines. Improved indicator of Watt.

(These pieces of apparatus are made to act under the eyes of the pupils.)

Work of Animal Prime Movers upon Machines.

Results of experience as to the values of the daily work which animal motors can supply under different circumstances without exceeding the fatigue which sleep and nourishment are capable of repairing.

Theory of the Transmission of Work in Machines.

Principal resistance. Secondary resistances. Two manners in which bodies perform the duty of motors. Ratio of work done to work expended always inferior to unity. Different parts of machines; receivers; organs of transmission; tools as machines.

Calculation of the Work due to the passive resistances in machines.

Résumé of the notions previously acquired on friction. Application to the inclined plane, to the printing-press, to guides or grooves, to the screw with a square thread; different cases of uniform motion being impossible under the action of forces of given directions. Friction of trunnions, pivots, eccentrics, and insertions of winch-handles. Prony's dynamometrical brake; conditions of its application. Resistance to rolling; its laws according to experiment. Use of rollers and friction-wheels; their practical inconveniences.

Mixed friction of toothed wheels; the Dobo escapement: friction of the teeth in the endless screw.

Stiffness and friction of cords. Results of experience. Friction of cords and straps running round drums. Different applications; brakes; transmission by cords, endless straps, or chains.

Examples and exercises; effects of passive resistances in the capstan, the crane, pulleys, &c.

LESSON 40. *Revision.*

SECOND YEAR.

PART I.—DYNAMICS.—DYNAMICS OF A MATERIAL POINT.

LESSONS 1—2. *Compilation of the Notions acquired on this Subject.*

Differential equations of the motion of a material point submitted to the continued action of one or more forces. The acceleration of the projection of a point upon any axis or plane is due to the projection of the forces on this axis or plane. The acceleration along the trajectory is due to the tangential force. Relation of the curvature to the centripetal force. Introduction of the force of inertia into the preceding enunciations.

The increase of the quantity of motion projected upon an axis or taken along the trajectory is equal to the impulsion of the projected resultant, or to that of the tangential force. The total impulsion of a force is got by methods of calculation and of experiment analogous to those which relate to *work*. The increase of the moment of the quantity of motion in relation to any axis is equal to the total moment of the impulsions of the forces during the same interval of time; direct geometrical demonstration of this theorem. In decomposing the velocity of the moving body into a velocity in the plane passing through the axis of the moments, and a velocity of revolution perpendicular to this plane, we may replace the moment of the quantity of motion in space by the quantity of motion of revolution. Particular case known under the name of the principle of areas.

Extension of the preceding theorems to the case of relative motions. Apparent forces which must be combined with the real ones that the relative motion of a point may be assimilated to an absolute motion. Particular case of relative equilibrium. Influence of the motion of the earth upon the accelerating force of gravity.

DYNAMICS OF ANY MATERIAL SYSTEMS.

LESSONS 3—8.

Principle or general rule which reduces questions in dynamics to questions in equilibrium by the addition of the forces of inertia to the forces which really

act on the system. Equation of virtual work which expresses this equilibrium; it comprises in general the external and internal forces.

General Theorems.

These theorems, four in number, are founded upon the principle of the equality of action and reaction applied to internal forces. They may be deduced from the preceding rule, but the three last are obtained more simply by extending to a system of material points analogous theorems established for isolated material points.

General theorem of the motion of the center of gravity of a system. Particular case called *principle of the conservation of the motion of the center of gravity.*

General theorem on the quantities of motion and impulsions of exterior forces projected on any axis.

General theorems of moments of quantities of motion and impulsions of exterior forces, projected on any axis whatever.

General theorems of the moments of quantities of motion and impulsions of exterior forces about any axis. Analogy of these two theorems with the equations of the equilibrium of a solid, in which the forces are replaced by impulsions and quantities of motion.

Composition of impulsions, of quantities of motion, or the areas which represent them. All the equations which can be obtained by the application of the two theorems relative to quantities of motion and impulsions, reduce themselves to six distinct equations. Particular case called *principle of the conservation of areas.* Fixed plane of the resulting moment of the quantities of motion called *plane of maximum areas.*

General theorem of work and *vis viva.* Part which appertains to the interior forces in this theorem. Particular case called principle of the conservation of *vires vivæ*, where the sum of the elements of work done by the exterior and interior forces is the differential of a function of the co-ordinates of different points of the system. Application of the theorem of work to the stability of the equilibrium of heavy systems.

Extension of the preceding theorems to the case of relative motions. Particular case of relative equilibrium. Motion of any material system relative to axes always passing through the center of gravity, and moving parallel to themselves. Invariable plane of Laplace. Relation between the absolute *vis viva* of a material system, and that which would be due to its motion, referred to the system of movable axes above indicated.

Examples and Applications.

The following examples, amongst others, to be taken as applications or subjects of exercises relative to the general principles which precede.

Walking. Recoil of guns. Eolypile. Flight of rockets.

Pressure of fluid veins, resistance of mediums, &c. Direct collision of bodies more or less hard, elastic, or penetrable. Exchange of quantities of motion. Loss of *vis viva* under different hypotheses. Influence of vibrations and permanent molecular displacements.

Pile driving; advantage of large rammers. Comparison of effects of the

shocks and of simple pressures due to the weight of the construction. Oblique collision, and ricochet. Data furnished by experiment.

Oscillations of a vertical elastic prism suspended to a fixed point, and loaded with a weight, neglecting the inertia, and the weight of the material parts of this prism. Case of a sudden blow. What is meant by the "*resistance vive*" of a prism to rupture? Results of experiments.

Work developed by powder upon projectiles, estimated according to the *vis viva* which it impresses on them, as well as upon the gun and the gases upon hypothesis of a mean velocity.

SPECIAL DYNAMICS OF SOLID BODIES.

LESSONS 9—12. *Simple Rotation of an invariable Solid about its Axis.*

In applying to this case the first general rule of dynamics, the theorem of the moments of the quantities of motion, and the theorem of work, we are led to the notion of the moment of inertia; explanation of the origin of this name. The angular acceleration is equal to the sum of the moments of the exterior forces divided by the moment of inertia about the axis of rotation. Sum of the moments of the quantities of motion relative to this axis. *Vis viva* of a solid simply turning about an axis. What is meant by *radius of gyration*?

Remind of the geometrical properties of moments of inertia, of the ellipsoid which represents them, of the principal axes at any point, of those which are referred to the center of gravity.

Pressure which a rotating body exercises on its supports. Reduction of the centrifugal and tangential forces of inertia to a force which is the force of inertia of the entire mass accumulated at the center of gravity, and a couple.

Particular case where the forces of inertia have a single resultant; different examples. Center of percussion. Compound pendulum; length of the corresponding simple pendulum. Center of oscillation; reciprocity of the centers or axes of suspension and oscillation. Pressure upon the axis. Influence of the medium; experience proves that the resistance, varying with the velocity, changes the extent of the oscillations, but does not sensibly affect the time. Experimental determination of the center of oscillation and the moment of inertia about an axis.

Motion of an invariable Solid subject to certain Forces.

General notions on this subject. Motion of the center of gravity; motion of rotation about this point.

LESSONS 18—19. *Various Applications.*

Motion of a homogeneous sphere or cylinder rolling upon an inclined plane, taking friction into account.

Motion of a pulley with its axis horizontal, solicited by two weights suspended vertically to a thread or fine string passing round the neck of the pulley, the axle of which rests upon movable wheels. Atwood's machine serving to demonstrate the laws of the communication of motion.

Motion of a horizontal wheel and axle acted on by a weight suspended vertically to a cord rolled round the axle, or upon a drum with the same axis, and presenting an eccentric mass. To take account of the variable friction of the

bearings, and the stiffness of the cord, with recourse, if necessary, to approximation by quadratures. Oscillations of the torsion balance.

Balistic pendulum. Condition that there may be no shock on the axis. Experimental determination of the direction in which the percussion should take place.

Theory of Huyghen's conical pendulum considered as a regulator of machinery. How to take account of the inertia and friction of the jointed rods, as well as of the force necessary to move the regulating lever, &c.; appreciation of the degree of sensibility of the ball apparatus with a given uniform velocity.

Windlass with fly-wheel. Dynamical properties of the fly-wheel. Reduced formulæ for a crank with single or double action. Advantages and disadvantages of eccentric masses. Tendency of the tangential forces of inertia to break the arms. Numerical examples and computations.

Mutual action of rotating bodies connected by straps or toothed wheels in varying motion.

The wedge and punching-press. Stamping screw or lever used in coining, cams, lifting a pile or a hammer. To take account of the friction during the blow, and afterwards to estimate the loss of *vis viva* in cases which admit of it.

PART II.—SPECIAL MECHANICS OF FLUIDS.—HYDROSTATICS.

LESSONS 20—22.

Principle of the equality of pressure in all directions. Propagation of the pressures from the surface to the interior of a fluid, and upon the sides of the vessel. Equations of equilibrium for any set of forces. Pressure exerted in the containing orifices. Measure of the pressure upon a plain portion of surface inclined or vertical (sluice-gate, embankments, &c.) Center of push or pressure. Pressure against the surfaces of a cylindrical tube. Effect, and resistance to oppose to the pressure. Manometer and piezometer. Equilibrium of a body plunged in a heavy fluid or floating at its surface. Stability of floating bodies. Metacenter. Laws of the pressure in the different atmospheric strata.

HYDRAULICS.

LESSONS 23—27. *Flow of Fluids through small Orifices.*

Study of the phenomena which accompany this flow in the case of a thin envelop and a liquid kept at a constant level. Conditions of this constancy in the level, and the permanence of the motion in general. Motion of the lines of fluid; form; contraction; reversal and discontinuity of liquid veins. Fundamental formulæ for liquids and gases based upon the principle of *vis viva*, and Bernouilli's hypothesis of parallel sections or Borda's of contiguous threads. Torricelli's theorem relative to small orifices. What is called the theoretical expenditure, effective expenditure, and co-efficient of geometrical contraction. Co-efficient deduced from the effective expenditure. Its variations with the volume of the fluid contents, and the form of the inner surfaces of the reservoir. Results of the experiments of Michelotti, Borda, Bossut, &c. Phenomenon of adjutages. Venturi's experiments; influence of atmospheric pressure; loss of *vis viva;* reduction of the velocity and augmentation of the expenditure. Results of experience relative to the co-efficient of expenditure, the form and range of the parabolic jets, showing the initial *vis viva*, and the loss of *vis viva*.

Large orifices.—Sluice holes and floodgates; reservoirs or open orifices; expenditure; practical formulæ and results of experiment. Influence of the proximity of the sides and the walls. Arrangement to avoid the effects of contraction or the losses of *vis viva*.

Flow through conducting Pipes and open Canals.

Practical formulæ relative to the case of uniform sections of great length. Measure of the pressures at different points of a conduit-pipe. Expression for the losses of effect due to corners and obstructions. Flow of gases. Principal methods of measuring the volume consumed adopted in practice. Floats. Pitot's tube. Woltman's mill. Register mill in air or gas. Waste in such instruments. Modulus and scale for water-supply.

PART III.—DIFFERENT MACHINES CONSIDERED IN THE STATE OF MOTION.

Lesson 26. *General Considerations. Résumé of the Notions acquired on this Subject.*

Equation of *vis viva*, and transmission of work in machines, account being taken of the different causes of power and resistance. Physical constitution of machines; *receiver*, *communicators*, and *operator*. Influence of the weights, of frictions, of shocks, and any changes in the *vis viva*. Parts with continuous or uniform motion, with alternating or oscillating motion. Laws of the motion on starting from rest, and when the stationary condition is established. The positions to which the maximum and minimum of the *vis viva* correspond are those in which there is equilibrium between all the forces, exclusive of the forces of inertia. Advantage of uniform or periodic motion. General methods for regulating the motion; symmetrical distribution of the masses and strains; flys and various regulators. Brakes and moderators; their inconveniences. Object and real advantages of machines.

Lessons 27—35. *Hydraulic Wheels.*

Vertical wheels with float-boards, with curved ladles, and with spouts. Figure of the surface of the fluid in these latter. Horizontal wheels working by float-boards, buckets, and reaction. Turbines. Description, play, and useful effects compared according to the results of experiment. Vertical wheels of windmills and steamboats. Screw propeller.

Windmills.

Description. Result of Coulomb's observations.

On the principal kinds of Pumps.

Special organs of pumps. Valves and pistons, force pump, sucking pump; limit to the rise of the water. Sucking and force pump. Dynamical effects. Indication as to the losses of *vis viva* and the waste in different pumps. Explanation of the hydraulic ram. Air vessel. Fire pumps. Double action pumps.

Various Hydraulic Machines.

Hydraulic press. Water engine. Exhausting machines; *norias;* under and overshot wheels; Archimedes' screw, construction and experimental data.

Lessons 36—39. *Steam Engines.*

Succinct description of the principal kinds of steam-engine with or without detent. Effects and advantages of the detent. Condenser. Air Pump. Furnace and feeding-pump.

Variable detent. Formulæ and experimental results.

Lessons 40—42. *Revision.*

Reflections on the totality of the subjects of the course.

IV. PHYSICS.—*FIRST YEAR.*

GENERAL PROPERTIES OF BODIES.—HYDROSTATICS.—HYDRODYNAMICS.

Lessons 1—5. *Preliminary Notions.*

Definitions of physics. Phenomena. Physical laws. Experiments are designed to make them spring out of the phenomena. Method of induction. Physical theories; different character of the experimental and mathematical methods.

General Properties of Bodies.

Extension. Measure of lengths. Vernier. Cathetometer. Micrometer screw. Spherometer. Dividing engine.

Divisibility. Porosity. Ideas generally received on the molecular constitution of bodies. These conceptions, which are purely hypothetical, must not be confounded with physical laws. Elasticity. Mobility. Inertia. Forces; their equilibrium, their effects, their numerical estimation.

Weight or Gravity.

Direction of gravity Plumb-line. Relation between the direction of gravity and the surface of still water.

Weight. Center of gravity.

Experimental study of the motion produced by weight. In vacuum, all bodies fall with the same velocity. Disturbing influence of the air. Inclined plane of Galileo. Atwood's machine. To prove by experiment; 1° the law of the spaces described; 2° the law of velocities. Morin's self-registering apparatus with revolving cylinder.

Law of the independence of the effect produced by a force upon a body, and the motion anteriorily acquired by this body. Law of the independence of the effects of forces which act simultaneously upon the same body. Experimental demonstration and generalization of these laws. Law of the equality of action and reaction.

Mass. Acceleration. For equal masses the forces are as the accelerations which they produce. Relation between the force, mass, and acceleration. Collision.

General laws of uniformly accelerated motion. Formulæ.

Pendulum. Law of the isochronism of small oscillations and law of the lengths deduced from observation.

Method of coincidences or beats. Use of the pendulum as the measure of time. Simple pendulum; formulæ. Compound pendulum: the laws of the oscillations of a compound pendulum are the same as the laws of the oscillations of a simple pendulum whose length may be calculated.

Determination by means of the pendulum of the acceleration produced by gravity. This acceleration is independent of the nature of the body.

Remark that the formulæ for the motion of oscillation apply to the comparison of forces of any kind, that may be regarded as constant and parallel to themselves in all positions of the oscillating body.

Identity of gravity and universal attraction.

Measure of weights. Balance. Conditions to be attended to in making it. Absolute sensibility; proportional sensibility. Method of double weighing. Details of the precautions necessary in order to obtain an exact weight.

Different States of Bodies. Hydrostatics.

Solids. Cohesion. Transmission of external pressures.

Elasticity. The true laws of elasticity are unknown. Empirical laws in certain simple cases, and for a very small action. Elasticity of compression, extension, torsion. Experimental determination of the co-efficients of elasticity. Limits of elasticity. Limits of tenacity.

Ductility. Temper. Cold hammering. Annealing.

Liquids. Fluidity. Viscosity. Physical laws which form the basis of hydrostatics:—1° the transmission of external pressures is equal in all directions; 2° the pressure exercised in the interior of a liquid upon an element of a surface is normal to that element, and independent (as to amount) of its direction. These principles are demonstrated by the experimental verification of the consequences drawn from them.

Application to heavy liquids. Free surface, and surface *de niveau*. Pressure upon the parts of the containing vessel, and upon the bottom in particular; hydrostatic paradox; verificatory experiments. Haldat's apparatus. Hydrostatic press.

Application to immersed or floating bodies (principle of Archimedes;) verificatory experiments. (In treating of the equilibrium of floating bodies, the conditions of stability are not gone into.)

Superposed liquids.

Communicating vessels. Water level. Spirit level; its use in instruments.

Densities of solids and liquids. Anemometers.

Compressibility of liquids. Piezometer. Correction due to the compressibility of the solid envelop.

Gas. Expansibility. Other properties common to liquids and gases. Principle of the equal transmission of pressures in all directions. Weight of gases. Pressure due to weight (principle of Archimedes.) Weight of body in air and in vacuum. Aerostation.

Superposed liquids and gases.

Communicating vessels. Barometer.

Detailed construction of barometer. Barometers of Fortin, Gay-Lussac, Bunten. Indication of the corrections necessary.

Mariotte's law. Regnault's experiments.

Manometer with atmospheric air—with compressed air. Bourdon's manometer.

Law of the mixture of gases.

Air pump. Condensing pump.

Primary Notions of Hydrodynamics.

Toricelli's principle. Mariotte's vessel and syphon. Uniform flow of liquids. The same of gases.

Molecular Phenomena.

Cohesion of liquids. Adhesion of liquids to solids. Capillary phenomena. Apparent attractions and repulsions of floating bodies.

Adhesion of drops.

Molecular actions intervene as disturbing forces in the phenomena of the equilibrium and motion of liquids.

HEAT.

EFFECTS OF HEAT ON BODIES.

Lessons 6—9. *Generalities.*

General effects. Arbitrary choice of one of these effects to define the thermometric condition of a body. Conventional adoption of a thermometer. Definition of temperature.

Dilating Effects.

Definition of the co-efficients of linear, superficial, and cubic dilatation. Approximate relation between the numerical values of these three co-efficients. The value of the co-efficient of dilatation depends upon the thermometric substance and the temperature selected as the zero point. It becomes nearly independent of the zero point when the co-efficient is very small.

Relation between volume, density, and temperature. Linear dilatation of solid bodies. Ramsden's instrument. Cubical dilatation of liquids. Dulong and Petit's experiments on mercury. Discussion. Regnault's experiments.

Cubical dilatation of solids and of other liquids when that of mercury is given.

Relations between the volume, density, and elasticity of a gas, and its temperature.

Cubical dilatation of gases. Experiments of Gay-Lussac, Rudberg, and M. Regnault. Advantage of varying the methods of experimenting in these delicate researches.

Methods based upon the changes of volume under a constant pressure, and upon the changes of pressure for a constant volume.

The disagreement of these two methods is due to deviations from the law of Mariotte.

The constancy of the co-efficients of dilatation previously defined is only approximately true.

Necessity of employing two different co-efficients of dilatation according as consideration is being had to the variations of volume to a given pressure, or of pressure to a given volume.

Empirical formulæ for the dilatation of liquids.

Graphical constructions.

Lesson 10. *Thermometers.*

Construction of thermometers. Mercurial thermometer. Details of construction. Fixed points. Different scales; their relation. Arbitrary scales.

Change which takes place in the zero point. Different precautions to be observed in using the mercurial thermometer.

General want of comparability of mercurial thermometers with tubes of different material.

Air thermometers. They are comparable with one another within the limits of the errors of experiment, whatever the nature of the tube employed. This property entitles the air thermometer to a preference for all accurate measures. Comparison of the air and mercurial thermometers.

THERMOSCOPE, DIFFERENTIAL THERMOMETER, PYROMETERS, BREGUET'S THERMOMETER.

LESSONS 11—13. *Changes of State produced by Heat.*

Exposition of the phenomena which accompany the liquefaction of solids and the solidification of liquids. Constancy of the temperature whilst the phenomenon is going on.

Sudden melting and freezing. Persistance of the liquid state beneath the melting point.

Influence of pressure.

Exposition of the phenomena which accompany the conversion of liquids or solids into vapor, and the inverse passage from the gaseous to the liquid or solid state. Constancy of the temperatures whilst the phenomenon is going on.

Influence of pressure.

Phenomena of ebullition in free space. Augmentation of the temperature and pressure in a confined space. Papin's digester.

Properties of vapors in spaces and in gases. Saturated vapors. Their tension does not depend upon the space which they occupy, but only upon their temperature.

Effects of a diminution or increase of pressure without change of temperature; the same without change of pressure. Effects of lowering the temperature in a limited region of space occupied by vapor.

Tension of a saturated vapor at the boiling point of its liquid.

Measure of the tensions of the vapor of water. Experiments of Dalton, Gay-Lussac, Dulong, and Arago, and of M. Regnault.

Tables of the tensions of steam. Empirical formulæ. Graphical constructions.

It is assumed that non-saturated vapors are subject to the same laws as gases.

APPLICATIONS. CORRECTION OF THE BOILING POINT IN THE CONSTRUCTION OF THERMOMETERS. BAROMETRICAL THERMOMETERS.

LESSONS 14—16. *Various Applications of the Laws previously established.*

A phenomenon can not always be separated from the accessory phenomena which concur with it in producing the final result. Necessity of corrections to render complex results comparable *inter se*.

Density of solids when regard is had to the temperature and weight of the gases displaced by them.

Precautions to be attended to in the experiments. Empirical formulæ for the

density of liquids. Maximum density of water. The temperature corresponding to the maximum must be determined graphically, or by interpolation.

Corrections for measures of capacity, for barometric measures.

The uncertainty of the corrections can not, in any considerable degree, affect the densities of solids and liquids.

Density of gases. Biot and Arago's experiments. Special difficulties of the question. The uncertainty of the corrections may sensibly affect the results. Regnault's method.

The same method may be applied to the determination of the co-efficient of dilatation for gases.

Density of vapors. Definition founded on the hypothetical application of the same laws to gases and vapors. Formulæ. Experimental method of Gay-Lussac and of Dumas. Corrections. Comparison of the two methods. Necessity of conducting the experiments at a distance from the saturation point. Latour's experiments. Relations between the weight and volume of a gas, and its temperatures; between the weight and volume of a gas mixed with vapors, and its temperature. Various problems.

Hygrometry. Chemical hygrometry. Hygrometry by the dew-point. Psychrometry.

PROPAGATION OF HEAT.

Lessons 17—18. *Propagation at a Distance.*

Rapid propagation of heat at a distance, in vacuum, in gases, in certain liquid or solid mediums. Experiments which establish this.

Rays of heat. Velocity of propagation. Intensity of heat received at a distance. Intensity of heat received or emitted obliquely. Emitting power, power of absorption, reflection, diffusion. The emitting and absorbing power are expressible by the same number in terms of their proper units respectively.

Analysis of calorific radiations by absorption. Different effects of deathermanous or thermochroic medium. Different influences of increasing thicknesses of the combination of different mediums. Radiations proceeding from different sources, various effects of different mediums on these radiations.

The calorific radiations emanating from different sources, have all the characters of differently colored heterogeneous rays of light.

THEORY OF RADIATION AND OF THE DYNAMICAL EQUILIBRIUM OF TEMPERATURES. APPARENT REFLECTION OF COLD.

Lesson 19. *Law of Cooling.*

Definition of the rate of cooling. Many causes may conspire in the cooling of a body.

Cooling in space. Newton's law only an approximation. Experimental investigation of the true law. Method to be followed in this investigation. The velocity of cooling is not a *datum* directly observable. It must be deduced provisionally from an empirical relation between the temperature and the time. Preliminary experiments. Course of the definitive experiments. Elementary experimental laws.

Hypothetical form of the function which expresses the velocity of cooling. To determine by means of the preceding experimental laws the unknown form

of the function which expresses the law of radiation. Relation between the temperatures and the times. This relation only contains data immediately observable, and may be verified *à posteriori*.

The contents which enter into the preceding relation depend upon thermometric constants and the nature of the radiating surface.

The contact of a gas modifies the law of cooling.

Lessons 20—21. *Propagation by Contact.*

Slow propagation of heat in the interior of bodies, in solids, liquids, and gases. Confirmatory experiments. Hypothesis of partial radiation. Theoretical law resulting from this hypothesis upon the decrease of temperatures in a solid limited by two indefinite parallel planes maintained at constant temperatures. Determination of the co-efficient of conductibility by the experimental realization of these conditions. This experiment determines a numerical value of the co-efficients; it is not of a nature to serve as a check upon the theoretical principles. Enunciation of the law resulting from the same theoretical principles upon the decrease of temperatures in a thin bar heated at one end.

CALORIMETRY.

Lessons 22—23. *Specific Heats.*

Comparison of the quantities of heat. The quantities of heat are not proportioned to the temperatures. Definitions of the unity of heat. General method of mixtures to estimate the quantities of heat. Experimental precautions and corrections.

Application of the general method of mixtures. Specific heats of solids and liquids. Law of the specific heat of atoms. Heat absorbed by expansion, restored by the compression of bodies. Experiments on gases. Specific heats of gases under constant pressure. Measure of specific heats of gases under constant pressure. Special difficulties of the question. Succinct indication of one of the methods. Specific heats to a constant volume.

Lesson 24. *Latent Heat.*

Component heat of liquids absorbed into the *latent* state during fusion, restored to the *free* state during solidification.

Influence of the viscous state. Latent heat of ice. Ice calorimeter; its defects.

Component heat of vapors, absorbed into the latent state during vaporization, restored to the free state during condensation. Measure of the latent heat of vapors. Regnault's experiments.

Empirical laws on the latent heat of vaporization.

Applications of Calorimetry.

Means of producing heat or cold; 1, by changes in density; 2, by changes of state. Freezing mixtures. Vaporization of liquids. Condensation of vapors.

Steam-boilers. Warming by hot air and hot water. Various problems. Sensations produced by a jet of vapor.

Different physical and chemical sources of heat; percussion, friction, chemical combinations, animal heat, natural heat of the globe, solar heat, &c. It will be

remarked that mechanical work may become a source of heat, and heat a source of mechanical work.

STATICAL ELECTRICITY.—MAGNETISM.—STATICAL ELECTRICITY.

Lessons 25—27.

General phenomena. Distinction of bodies into conductors and non-conductors. Distinction of electricity into two kinds. Separation of the two electricities by friction. Hypothesis of electric fluids. Effects of vacuum of gases and vapors of points. Electrical attractions and repulsions. Electrization by influence. Case where the influenced body is already electrized. Sparks; power of points. Electrization by influence preceding the motion of light bodies.

Electroscopes.

Electrical machines of Van-Marum, Nairne, Armstrong.

Condenser. Accumulation of electricity upon its surface. Leyden jar. Batteries. Electrical discharges. Effects of electricity.

Condensing electroscope. Electrophorus.

Velocity of statical electricity.

Atmospherical electricity. Phenomena observed with a serene sky. Electricity of clouds. Storms. Lightning. Thunder. Effects of thunder. Return-shock. Lightning conductor.

Different sources of statical electricity.

MAGNETISM.

Lessons 28—30.

Natural magnets. Action upon iron and steel. Artificial magnets. The attractive action appears as if it were concentrated about the extremities of magnetic bars. First idea of poles.

Direction of a magnetized bar under the earth's action. Reciprocal action of the poles of two magnets. Names given to the poles.

Phenomena of influence. Action of a magnet upon a bar of soft iron; upon a bar of steel. Coercive force. Effects of the rupture of a magnetized bar. Theoretical ideas on the constitution of magnets. More precise definition of the poles.

Action of the earth upon a magnet. The earth may be considered as a magnet. Its action may be destroyed by means of a magnet suitably placed. Astatic needles. The magnetic action of the earth is equivalent to a *couple*. Three constants define the couple of terrestrial action. Declination. Inclination. Intensity. Measure of the declination; of the inclination.

Magnetic metals. Influence of hammering, tempering, &c. Methods of magnetizing. Saturation. Loss of magnetism. Influence of heat. Magnetic lines. Armatures.

Magnetization by the earth's influence. Means of determining the magnetic state of a body.

Measure of Magnetism and Electricity.

Lessons 31—32.

Coulomb's balance. Distribution of magnetism on a magnetised bar; distri-

bution of electricity at the surface of isolated conductors. Comparative discussion of the conditions of the two problems and the methods of experiment.

Laws of the magnetic attractions and repulsions. Law of electric attractions and repulsions. Comparative discussion of the conditions of the two problems, and the methods of experiment.

Determination of the law of magnetic attractions and repulsions by the method of oscillations.

Comparison of the magnetic intensity at different points of the earth's surface.

LESSONS 33—34. *Revision.*

Considerations on the totality of the subjects of the course.

SECOND YEAR.

DYNAMICAL ELECTRICITY.—GALVANISM.

LESSONS 1—2

Chemical sources of electricity. Experimental proofs. Arrangement devised by Volta to accumulate, at least in part, at the extremities of a heterogeneous conductor the electricity developed by chemical actions.

Pile. Tension at the two isolated extremities; at one single isolated extremity; at the two extremities reunited by a conductor. Continuous current of electricity. Poles. Direction of the current, &c.

Various modifications of the pile of Volta. Woollaston's pile, Münch's pile, &c. Dry piles; their application to the electroscope.

Principal effects of electricity in motion, and means of making the currents perceptible. Experiment of Oersted. Galvanoscopes.

Currents produced by heat in heterogeneous circuits. Thermo-electric piles. Thermometric graduation of thermo-electric piles.

Currents produced by the sources of statical electricity.

PROPERTIES OF CURRENTS.

LESSON 3.—1. *Chemical Actions.*

Definitions. Phenomena of decomposition and transference. Reaction of the elements transferred upon electrodes of different kinds.

Principles of electrotyping.

Causes of the variation of the current in ordinary piles; means of remedying this; Daniell's pile. Bunsen's pile.

LESSONS 4—8. 2. *Mechanical Properties.*

Reciprocal actions of rectilinear or sinuous currents parallel or inclined. Reaction of a current on itself.

Reciprocal actions of helices or solenoids. Continuous rotation of currents by their mutual action; by reaction. Analogy of magnets and solenoids. Electro-dynamical theory of magnetism. Action of magnets upon currents and solenoids. Action of currents upon magnets. Experiments of Biot and Savart. Continual rotation of a current by a magnet; of a magnet by a magnet.

Action of the earth upon currents; it acts as a rectilinear current directed from east to west, perpendicularly to the magnetic meridian.

Continual rotation of a current by the action of the earth.
Astatic conductors.

LESSONS 9—10. 3. *Magnetic Properties.*

Action of an interposed conductor upon iron filings.

Electro-magnets. Magnetization temporary or permanent. Principles of the electric telegraph. Electrometers. Reference to diamagnetic phenomena.

4. *Electro-motive Properties.*

Phenomena of induction by currents, by magnets. Phenomena of magnetism in motion. Induction of a current upon itself.

Induction of different orders.

Interrupted currents. Clarke's machine.

LESSON 11. 5. *Calorific Properties.*

Influence of the nature of the interposed conductor; of its section; of the intensity of the current. Unequal temperatures at the different junctions of a heterogeneous circuit.

6. *Luminous Properties.*

Incandescence of solid conductors. Spectrum of the electric light. Voltaic arc. Transfer of ponderable matter. Action of the magnet upon the Voltaic arc.

7. *Physiological Action of Currents.*

Some words on this subject. Muscles and nerves. Actions of discontinuous currents. Reotomic contrivances.

Reometry.

Compass of sines, of tangents. Experimental graduation of galvanometers.

The dynamical intensity of a current diminishes when the length of a current increases. Reostat.

Laws of the dynamical intensity of a current in a homogeneous circuit. Reduced length and resistance of a circuit. Specific co-efficients of resistance. Laws of the dynamic intensity of a current in a heterogeneous circuit.

The intensity of currents is in the inverse ratio of the total reduced length, and proportional to the sum of the electromotive forces. Formula of the pile. Discussion of the case of hydro-electric piles—thermo-electric piles. Conditions for the construction of a pile, with reference to the effects to be produced. Conditions for the construction of a galvanometer with reference to its intended application.

Laws of secondary currents in the simplest cases. The chemical intensity of a current is proportional to its dynamical intensity.

ACOUSTICS.

LESSONS 12—15.

Noise, sound, quality of the sound, pitch, intensity, *timbre*. A state of vibration in a solid, liquid, or gaseous body is accompanied with the production of sound.

The pitch depends on the number of vibrations. Unison. Instruments for

counting the vibrations:—1st. Graphic method. 2nd. Toothed wheels. 3rd. Lever. Feeling of concord. Musical scale. Gamut. Limit of appreciable sounds.

Study of vibrating motions in solids. Vibrating cords. Vibrations transversal, longitudinal. Experimental laws. Sonometer.

Spontaneous division of a cord into segments. Fundamental sounds. Harmonic sounds.

Staight and curved rods. Transversal and longitudinal vibrations. Experimental laws. Division into segments. Nodes. Ventral segments. Membranes.

Plane and curved plates. The vibrations divide them into "*concamerations.*" Nodal lines. Harmonic sounds.

Study of the vibrations in liquids and in gases.

Theoretical ideas upon the propagation of a vibratory motion in indefinite elastic media, on an indefinite cylindrical tube. Waves of condensation of dilatation. Progressive nodes and ventral divisions. Laws of the intensities of sound. Direct measure of the velocity of the propagation of sound in water. Measure of the velocity of the propagation of sound in air. Formulæ without demonstration. Comparison of the formulæ with experiment.

Sonorous waves reflected in an indefinite medium.

Fixed nodes and ventral divisions. Sonorous waves reflected in closed and open tubes. Fixed nodes and ventral divisions; the vibratory state and density thereat.

Series of sounds afforded by the same tube. Effect of holes.

Sonorous reflected waves in rods. Series of sounds afforded by the same rod vibrating longitudinally. Indirect measure of the velocity of sound in gases, liquids, and solids.

Experiments on the communication of vibrating motion in heterogeneous mediums, on the general direction of the vibrating motion communicated.

Intensification of sounds. Interferences. Beats. Different stringed and wind instruments. Means of setting them in vibration.

A few words on the organs of voice and hearing. Incompleteness of our knowledge on this subject.

OPTICS.

Lessons 16—17. *Propagation of Light.*

Propagation of light in a straight line. Rays of light. Geometrical theory of shadows. Velocity of light. Rœmer's observations. Laws of intensity of light. Photometers of Bouguer, Rumford. Intensity of oblique rays. Comparison of illuminating powers. Total brightness. Intrinsic brightness.

Reflection.

Reflection of light: its laws. Experimental demonstration. Images formed by one or more plane mirrors. To ascertain if a looking-glass has its two faces parallel.

Spherical mirrors. Foci, formulæ. Discussion. Images by reflection. Measure of the radius of a spherical mirror.

Definition of caustics by reflection. Definition of the two spherical aberrations in mirrors.

Woollaston's goniometer.

LESSON 18. *Refraction.*

Refraction of light in homogeneous mediums. Descartes' law. Experimental demonstration for solids and liquids.

Inverse return of the rays. Successive refractions. Indices of transmission in terms of the principal indices. Consequences of Descartes' law. Total reflection. Manner of observing it.

Irregular refractions. Mirage.

Refraction is always accompanied with the accessory phenomenon of dispersion.

Geometrical consequences of the law of refraction. Focus of a plane surface. Focus of a medium bounded by two parallel plane surfaces; by two plane surfaces inclined in the form of a prism.

Foci of a spherical surface; of a medium limited by two spherical surfaces. Lenses.

Formula for lenses. Discussion. Varieties of lenses. Optic center. Images. Measure of the focal distance of lenses.

Definition of caustics by refraction. Definition of the two spherical aberrations of a lens.

LESSONS 19—20. *Dispersion.*

Unequal refrangibility of the differently colored rays which compose white light. Analysis of heterogeneous light by the prisms. Newton's method. Solar spectrum. Homogeneity of the different colors. Second refraction of a homogeneous pencil. Experiment with crossed prisms. Precautions to be attended to in the experiments. The spectrum, obtained by Newton's method, differs from the spectrum produced at the focus of a lens placed between the prism and the picture, according to the method of Fraunhofer. Reasons of the comparative purity of this latter spectrum. Fraunhofer's lines. Different spectra of different sources of heterogeneous light. Marginal iridescence of a large pencil of natural light traversing a prism. Dispersion of light by lenses. Iridescence of focal images. Recomposition of light, by means of a prism at the focus of a spherical mirror or a lens, by the rapid rotation of a plane mirror, by the rotation of a disk with party-colored sectors. Compound colors.

Chemical and calorific radiations accompany luminous radiations.

Analysis of light by absorption. Characteristic action of transparent colored mediums upon different sorts of compound light. Different influences of increasing thickness. Effects of differently colored mediums upon heterogeneous light. Effects of differently colored mediums upon homogeneous rays separated by the prism.

LESSON 21. *Measure of the Indices of Refraction.*

Determination of the indices of refraction.

1. In solids. Measure of the refracting angles. Minimum of deviation. Measure of the corresponding deviation. Use of Fraunhofer's lines.

2. In liquids.

3. In gases. Special difficulties of the question. Experimental method. Biot's and Arago's experiments.

Any power whatever of the index of refraction diminished by unit is sensibly proportional to the density of the gas. Method of Dulong founded on this remark.

LESSONS 22—23. *Application of the preceding Laws.*

Rainbow. Different orders of bow.

Achromatism.

Achromatic prisms. Diasperometer achromatism of lenses; how to verify it. Definition of secondary spectra: their nature gives the means of recognizing, whether flint or crown glass predominates, in an imperfectly achromatic lens.

Instruments essentially consisting of an achromatic lens. Magic lantern; megascope; solar microscope; camera obscura; collimators.

Vision.

Summary description of the principal optical parts of the eye. They act like the lens of a camera obscura to form an image upon the retina. Distinct vision; optometers; short sight; long sight; spectacles.

Binocular vision; perspective peculiar to each eye; estimation of distances; sensation of solidity; stereoscope; estimation of magnitudes.

PERSISTENCE OF IMPRESSIONS; DIVERS EXPERIMENTS.

LESSONS 24—26. *Optical Instruments.*

Camera lucida. A lens is necessary to reduce to the same apparent distance the two objects seen simultaneously. Instruments to assist the sight; simple microscope; the magnifying power; distinctness; field; advantage of a diaphragm; it modifies the field and the brightness variously according to its position.

Woollaston's double glass; its advantages.

General principle of compound dioptrical instruments.

Compound microscope; experimental measure of its magnifying power, by means of the diaphragm, by means of the camera lucida.

Astronomical telescope; object glass; simple eye-glass. Necessity for a diaphragm; its place; the wires, their place; optic axis of a telescope. Parallax of the threads of the wires; magnifying power of the object-glass; of the eye-glass; field of view of a telescope.

Optic ring; different methods of measuring the magnifying power.

Distinctness of a telescope; night-glass.

Different distances of drawing out the eye-glass for short-sighted and long-sighted observers.

Different sorts of eye-pieces; positive eye-pieces; ordinary double eye-piece of the astronomical telescope. Ramsden's eye-piece; treble eye-piece of the terrestrial telescope. Negative eye-pieces; simple eye-piece of Galileo. Compound *ditto* of Huyghens; advantages and disadvantages of these different combinations; general principle of catadioptrical instruments.

LESSONS 27—29. *Double Refraction.*

Crystallised mediums do not all act upon light like homogeneous mediums.

Double refraction of Iceland spar: the extraordinary image turns round the ordinary image. The ordinary and extraordinary rays cross at the interior of the crystal.

Huyghens' construction; measure of the ordinary and extraordinary indices of refraction; attractive and repulsive crystals; a ray falling perpendicularly does not always bifurcate in a camera with parallel faces, nor in a prism. Definition of uniaxial and biaxial crystals.

The dispersion of the ordinary ray differs from that of the extraordinary ray.

The two rays are unequally absorbed in many colored mediums. Tourmaline.

Doubly-refracting prisms; their construction. Use of doubly-refracting prisms to measure apparent diameters, &c.

LESSONS 30—31. *Polarization.*

Successive refractions in doubly-refracting prisms. Special properties of the two rays emerging from the first doubly refracting crystal. Polarization by double refraction.

Reflection from transparent media polarizes the light partially or wholly according to the incidence. Brewster's law. Reflection of polarised light from a transparent medium.

Simple refraction partially polarizes the light. Many successive refractions polarize it almost totally. Piles of glasses.

Different methods to obtain a ray of polarized light, 1st, by reflection; 2nd, by simple refraction; 3rd, by double refraction, by eliminating one of the refracted pencils;—by a screen,—by total reflection, Nicol's prism, by absoption, tourmaline.

Distinctive characters of light completely or partially polarized.

LESSONS 32—34. *Theory of Undulations.*

Hypothesis of luminous undulations.

Vibratory state of a simple ray of homogeneous light. Vibratory state at the intersection of two simple rays of homogeneous light intersecting at a very small angle.

Experimental proofs in support of this hypothesis:

1st. Experiment with interferences, fringes. Their breadth is different for different colors; they give the various colors of the prism in white light. The alternately bright and dark sheets are hyperboloids of revolution. The measure of the fringes give the means of estimating the lengths of the undulations corresponding to different colors.

2nd. Colored rings of Newton, observed by reflection, by refraction. Law of the diameters; these vary in absolute length for different colors. Variously colored rings with white light. Reflected rings with a white spot at the center.

The theory of the undulations does not apply merely to theses phenomena. Explication of the laws of reflection and refraction. Definition of polarization in the system of waves. Elementary application of double refraction and the polarization which accompanies it in uniaxial crystals when the face of the crystal is parallel to the axis, and the plane of incidence normal or parallel to this axis.

Chemical and Calorific Radiations.

Chemical and calorific radiations are subject, like luminous radiations, to the laws of reflection, refraction, dispersion, double refraction, polarization, interferences.

LESSONS 35—36. *Revision.*

Considerations on the totality of the subjects of the course.

MANIPULATIONS IN PHYSICS.

The practical exercises which constitute the subject of this programme will be performed in part by the pupils under the direction of the professors and *répétiteurs*, in part by the professors and *répétiteurs*, with the coöperation of the pupils.

FIRST YEAR.

Use of various instruments, designed for measuring lengths. Experiments on weight with Atwood's machine, the inclined plane, Morin's apparatus, and the pendulum.

Some experiments on elasticity.

Various verifications of the principles of hydrostatics and hydrodynamics.

Construction of aerometers.

Construction of a barometer, of a manometer. Various verifications of the law of Mariotte.

Various experiments with the air-pump.

Determination the density of solids or liquids by different methods.

Construction of a thermometer.

Experiments on the dilatation of liquids and solids by means of the ordinary thermometer and by means of the statical thermometer.

Experiments upon the dilatation of air by various methods.

Experiments upon the tension of vapors by different methods.

Determination of the density of vapors and gases by various methods.

Leading experiments on calorific radiation.

Experiments on cooling.

Determination of specific heats, heats of fusion, heats at which bodies pass into vapor.

Cooling mixtures.

Use of the chemical hygrometer, the wet bulb hygrometer.

Rehearsal of the leading experiments on magnetism.

To magnetize a needle, to reverse its poles.

Rehearsal of the principal experiments of statical electricity.

Experiments verificatory of the laws of electricity and magnetism.

Use of compasses.

SECOND YEAR.

Experiments upon the chemical actions of poles.

Leading experiments in electro-dynamics.

Leading experiments upon the magnetic properties of currents.

Experiments on induction.

Experiments on the calorific and luminous actions of currents.

Quantitative experiments on the laws of currents.

Experiments on the propagation of sound; on the vibrations of rods of plane or curved plates, membranes, sonorous tubes.

Experiments on mirrors, plane or curved.

Experiments on lenses. Experiments on the decomposition of light by the prism—by absorption. Measures of the indices of the refraction of solids. Use of the magnifying glass and microscope; measure of the magnifying power. Use of different telescopes, with and without corrections. Measure of the magnifying power. Experiments on double refraction and polarization. Experiments on interferences and colored rings.

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SCHOOL FOR ARTILLERY AND ENGINEERS

AT METZ.

HISTORY AND GENERAL DESCRIPTION.

The first French Artillery School was founded in the time of Louis XIV. (in 1679) at Douai. It had but a short existence: and it was only in 1720 (under the Regency,) when the Royal Regiment of Artillery received a new organization, that schools of theory were permanently founded in each of the seven towns where there were garrisons of artillery. But no academy properly so called was established before that founded by D'Argenson at La Fère, in 1756, with a staff of two professors of mathematics, and two of drawing. This was transferred to Bapaume, near the Flemish frontier, in 1766, re-transferred to La Fère, and suppressed, among other schools, at the beginning of the Revolution.

Of early Engineer Schools there was only one, the very distinguished School of Mézières, near the northern frontier. This was founded in 1749, also under the ministry of D'Argenson; Monge was a professor there; and it had a very high reputation down to its suppression in the Revolution.

When the wars of the Revolution broke out, Provisional Schools for giving a brief course of rapid instruction was established at Metz for the engineers, and at Châlons-sur-Marne for the artillery. These had to supply, at a great disadvantage, the officers needed for the protection of the invaded frontier.

It was intended originally that the Polytechnic, established in 1794, should send engineers direct to the army; but it was quickly found to be a better plan to allow the pupils destined for this service first to spend some little time at Metz; which thus, in October, 1795, became a School of Application for Engineers. The artillery pupils in like manner went to Châlons. This separate system of two Schools of Application continued till 1802, when the establishment at Châlons was united with that of Metz, and Metz became what it has since continued to be, the seat of the United School of Application for the two services. The Polytechnic students who

select the *Artillerie de terre*, *Artillerie de mer*, or the *Génie militaire*, enter here to receive the special and professional instruction deemed requisite to fit them for actual employment.

The students quitting the Polytechnic in the manner described in the account of that school, at the average age of twenty-one, enter the School of Application, with the provisional rank, the uniform, and the pay of sub-lieutenants (*sous-lieutenants.*) The ordinary term of residence is two years. Under special circumstances this may be shortened; and in case of illness or want of application individual students are occasionally retained for a third year. Each new body of students, each *admission* or *promotion*, is classified at the end of the first year, and the students composing it are arranged in order of merit in accordance with the reports of the professors, but without an examination; at the close of the second year they pass a final examination before the Board of Officers, and are definitively placed in the corps they have chosen, the artillery or engineers, according to the order of merit. They are allowed to count, as regards retirement from the service and towards military decorations, four year's service on account of the two years passed at the Polytechnic School, and of the time passed in preparing for admission to it, reckoning from the day of their admission to the School of Application.

Metz is a fortified place on the Prussian frontier, the seat of war at the time of the school's first foundation; it is on the line of railway to Mannheim, about thirty miles from the point where this branch diverges from the main line to Strasburg. The Moselle flows through the town, and is employed, with its little affluent the Seille, in the military defenses. The garrison numbers 10,000 men; there is an Arsenal, a school of Pyrotechny for the manufacture of rockets, two Regimental Schools, one of Artillery and the other of Engineers. The School of Application occupies buildings erected on the site, and partly the original buildings themselves, of a suppressed Benedictine monastery. Three sides of the cloistered monastic quadrangle are devoted to the offices, lecture-rooms, galleries and halls of study. A fourth, formerly the ancient church, is converted into a *salle des manœuvres*. There is an adjoining residence for the commandant; and a separate modern building, four stories in height, affords lodging to the young men.

The *salle des manœuvres* is a large area under a lofty roof, rising to the whole height of the buildings of the quadrangle; it contains artillery of various descriptions, mortars, field and siege guns placed as in a battery, and is amply large enough to allow cannon to be

moved and exercises performed when the state of the weather may make it desirable.

The amphitheaters or lecture rooms, much on the same system as those at the Polytechnic, are two in number, one for each of the two divisions. Officers of the artillery and engineers who are in garrison, are entitled, if they please, to attend the lectures, and other officers also may be admitted by permission.

The galleries, partly on the ground floor, partly on the first floor, contain very good collections of models of artillery, ancient and modern, of sets of small arms, of tools, of locks, barrels and other portions of muskets in various stages of the process of their manufacture, of specimens of carpentry and roofing, of minerals, of models of fortifications, bridges, coffer-dams, locks, &c.

The library on the first floor has an adjoining reading room; and near it is the examination room, of which further mention will be made. The three halls of study (*salles d'étude*) on the first floor are on a different plan from those of the Polytechnic, each one being large enough to accommodate a whole division (seventy students.) Three rooms are also provided for the professors to prepare their lectures in.

The barracks, on the opposite side of the open space used for drill and exercises, form a lofty and handsome building, entered by separate staircases, the ground-floor rooms of each being assigned to a servant, who undertakes to provide attendance for all the young men lodging in the rooms above. The rooms are comfortable, mostly double-bedded, the bedroom serving also as a sitting room, and a small adjoining closet being used for washing, &c. Twenty or twenty-two appear to be thus accommodated on each staircase; there are lodgings altogether for one hundred and forty-five. A certain number of the senior sub-lieutenants would, probably, on the arrival of the new cadets from the Polytechnic, be removed to lodge in the town.

There is a riding-school adjoining the court; stables, for thirty-three horses, which are kept for the use of the pupils, and lodgings for the attendants are provided in the neighborhood.

The mere description of the buildings shows at once that the system is different in many respects from that of the Polytechnic. Young men of twenty-one and twenty-two years of age, already holding provisional commissions in the service, receiving the pay and wearing the uniform of sub-lieutenants, are naturally allowed much greater freedom of action. They live, and partly also study, not in the halls of study, but in their own rooms; they take their

meals in the town, where they frequent the *cafés* and *restaurants* of their choice. The *rappel* summons them every morning to rise and attend a roll-call at half-past five or six; military exercises, riding, or interrogations, similar to the *interrogations particulières*, require the presence of a portion of the number, but the rest are free to return to their rooms. At ten they have to attend either the day's lecture, followed by employment in the halls of study, till four o'clock P. M., or they proceed at once to the halls of study, and set to work on the drawings, designs, projects, &c., which are described hereafter in the account of the studies. From four to half-past five P. M., drill, exercises, and riding occupy a portion of the number, probably those who were not called for in the morning. After half-past five they are left to themselves.

This ordinary routine of studies is interrupted in the summer months by the occurrence of expeditions for making surveys, and for measuring and sketching machines in manufactories. The young men are sent, two together, to survey (*lever à boussole ;*) singly for the reconnaissance sketch (*lever à vue ;*) and generally, a certain number are distributed about a district not too large for an officer to make his round in it, and see each day that all are at work. The railways afford considerable facilities; the expeditions never occupy more than ten days at a time, but they may be extended as far as Strasburg.

There are no *répétiteurs* in the school; but the system of *interrogations particulières* is carried on; and an examination by the professor and an assistant professor takes place after, about, every eight or ten lectures.

THE STAFF AND GOVERNMENT.

The Staff of the Institution consists of—

1 General Officer, at present a General of Brigade of Artillery, as Commandant.
1 Colonel or Lieutenant-Colonel, Second in Command and Director of Studies, at present a Lieutenant-Colonel of Engineers.
1 Major of Artillery.
1 Major of Engineers.
5 Captains of Artillery.
8 Captains of Engineers.
1 Surgeon (*Médecin-Major.*)

The Commandant is taken alternately from the Artillery and Engineers, and the command lasts for five years only.

The Second in Command is always chosen from that arm of the service which does not supply the Commandant.

The inferior officers of each rank are taken in equal numbers from the two arms.

The Staff of Instructors is as follows:—

1 Professor of Artillery, at present a Captain of Artillery.
1 Assistant ditto also a Captain of Artillery.
1 Professor of Military Art, charged also with the Course of Military Legislation and Administration (a Captain of Engineers.)
1 Professor of Permanent Fortification and of the Attack and Defense of places (a Captain of Engineers.)
1 Assistant ditto ditto (a Captain of Engineers.)
1 Professor of the Course of Topography and Geodesy (a Captain of Engineers.
1 Professor of Sciences applied to the Military Arts.
1 Professor of Mechanics applied to Machines (a Captain of Artillery.)
1 Professor of the Course of Construction (a Captain of Engineers.)
1 Assistant ditto.
1 Professor of the German language (a civilian.)
1 Professor of Veterinary Art and Riding (a Captain of Artillery.)
1 Assistant ditto (a civilian.)
1 Drawing Master, Chief of the Drawing Department (a civilian.)

In all, nine Professors, four Assistant Professors, and one Drawing Master.

The School employs in addition an administrative staff, consisting of—

A Treasurer, } both of whom must have been Officers in the Artillery or
A Librarian, } Engineers.
A Principal Clerk.
An Assistant Librarian.
Two Storekeepers, intrusted with the *matériel* belonging to the two arms.
One skilled Mechanic.
One skilled Lithographer.
One Fencing Master.

clerks and draughtsmen are provided as required.

The school is under the general superintendence of two boards or councils, the Superior Council and the Administrative Council.

The Superior Council consists of the General Commandant, as President, the Second in Command, the Director of Studies, as Vice-President; the Major of Artillery, and the Major of Engineers, as permanent members; two Captains of the Establishment, one of each arm; two Military Professors, one of each arm; and one Captain of the Establishment; these five last being all removable at the General Inspections.

The Superior Council has the duty of drawing up the programme of the studies of the year, of suggesting changes in the regulations relating both to studies and discipline, all subject to the approval of the Minister of War; of preparing at the end of the year the classified list of the students, drawn up according to their conduct and progress in their studies, and of pointing out to the Jury of Examiners any students who should go again through the courses

of the year, and stay in consequence an additional year at the school.

When questions relating to the instruction are brought before the Superior Council, the whole body of military professors attend and take part in the proceedings, and the Council is thus said to be constituted as a Board or Council of Instruction. Improvements are here suggested, and are subsequently submitted to the Jury of Examiners, and to the Minister of War; the value to be attached, in the system of marks or credits, to each particular course of study is determined; a statement is drawn up showing what printed works, models, &c., are wanted. The budget itself, to be submitted to the Minister of War, is finally drawn up by the Superior Council in its ordinary sittings.

The Administrative Council, composed of the Second in Command as President, the two Majors of Artillery and of Engineers, one Captain and one Military Professor, and the Treasurer as Secretary without the right of voting, takes cognizance of all the financial and other business matters of the school.

SUBJECTS AND METHOD OF STUDY.

The studies at Metz consist of topography and geodesy, including military drawing and surveying under special circumstances; field fortification, military art and legislation, permanent fortification, and the attack and defense of fortified places, accompanied by a sham siege, without, however, executing the details practically on the ground; architecture, as applicable to military buildings and fortifications; the theory and practice of construction, and artillery. The programmes of these studies are inserted at length in the Appendix.

The instruction is given principally (as at the Polytechnic) by means of a series of lectures, and the knowledge which the students have acquired is first directly tested by requiring them to execute various kinds of surveys of ground, either with or without the use of instruments; to prepare drawings of buildings, workshops, and machines in full detail (plan, elevation, and sections) from the measurements they have recorded in their note-books or on their sketches, and to accompany such drawings with descriptive memoirs of all particulars and calculations that may be necessary to exhibit their purpose or efficiency; to draw up projects and lay out works of field and permanent fortification, or of those of attack or defense of a particular place on certain given data, or according to the nature of the ground; to design a military building, bridge, ma-

chine, or piece of ordnance, accompanied by estimates and descriptive memoirs, showing in what manner the instructions and conditions under which it was drawn up have been complied with; and to prepare a project for the amelioration of the works of defense of a specified portion of a fortified place known to be defective in some respects.

The instruction during the first year's residence is common to the two arms; and the time is appropriated in the following manner, namely:—

	Days.
Military art and legislation,	33
Topography and geodesy,	47
Field fortification,	39
Permanent fortification,	88
Theory and practice of construction,	77
Total,	284

The *sous-lieutenants* who complete their first year's work are allowed nearly a month's vacation during November.

The instruction given to the Artillery and Engineers during the second year's residence is not entirely the same, as will be seen by comparing the accompanying table of the year's study:—

	Artillery. Days.	Engineers. Days.
Military art and legislation,	2	2
Topography and geodesy,	28	28
Attack and defense of places,	44	44
Permanent fortification,	44	129
Artillery, machines, &c.,	81	—
Theory and practice of construction,	46	42
	245	245
Brought forward from first year,	284	284
Total,	529	529

We should not omit to state that there is a short course on the Veterinary Art.

The lectures, as before said, begin at 10 A. M., and they last usually an hour and a half, and are followed by work in the halls of study. It would appear, however, that very frequently the day's occupation consists simply of work in the halls of study (or occasionally out of the school buildings, when the students are sent on some excursion;) and, accordingly, in giving the account of the studies, a *day* or day's work will sometimes mean a lecture followed by drawing or other employment, sometimes this drawing or other employment without any lecture preceding. Taking a general

average, the proportion appears to be about two lectures to five *séances*, *i. e.*, sittings without lectures.

The system will be better understood by referring to the accompanying tables, which are translated from the Project for the Employment of Time for the year 1851—2, submitted for the approval of the Minister of War. The dates in the first column indicate the days of the commencement of each particular study. The school year, it should be said, begins on the 1st of December.

EMPLOYMENT OF TIME FOR THE YEARS 1851—1852.

Month and Date.	Second Division. First Year's Instruction.	Number of Attendances.	Number of Lectures before Work.	Total of Lectures.
December 1	Lectures on Military Art in Topography—Conventional Tints,	2	.....	.....
" 2	Study of Hill Drawing (in sepia with contour lines,)	2	.....	.....
" 4	Military Art, Plate 1 ..... 5; Plate 2 ..... 5; Plate 3 ..... 5; Plate 4 ..... 5; Plate 5 9	29	4	29
" 6	Front of Cremontaige,	24	3	13
January 12	Project of Field Fortification, Plate 1. Plan of the whole, ... 3; Plate 2. Organization of a work, ... 8; Plate 3. Details of Construction, ... 4; Memoir, ... 4	19	5	7
February 9	Plan of Stability of Revetments, &c.,	9	9	9
March 3	Study of the Drawing showing the effect,	8	1	1
" 13	Plan of a Building, Out-of-door work, ... 9; Laying down and drawing, Memoir, 23	32	.....	.....
" 23	Topographical Triangulation,	4	4	6
April 29	Deblement and Profiling on the Ground,	3	.....	.....
May 5	Project of a Building, Sketches, ... 14; Drawing, ... 24; Memoir, ... 4; Estimate, ... 3	45	12	22
June 28	Survey with a plane-table, Out-of-door work, ... 0; Laying down and drawing, 3	13	1	.....
	One day free in case of bad weather,	1	.....	.....
July 14	To find the Variation of the Needle,	1	1	.....
" 17	Survey of Ground with the Compass, Out-of-door work, ... 8; Laying down and drawing, 2	10	1	.....
	One day free in case of bad weather,	1	.....	.....
August 2	Reconnaissance Plan—Out-of-door work,	6	1	.....
	One day free in case of bad weather,	1	.....	.....
" 10	Study of Shaded Drawing (*Hachures* and colored,)	8	1	.....
" 18	Laying down and drawing the Survey made with the Compass,	2	.....	.....
" 20	Project of Fortification on Level Ground, Plate 1 .... 6; Plate 2 .... 30; Memoir, ... 6	42	3	19
September				
October 8	Project of Fortification on Hilly Ground, Plate 1 ..... 19; Memoir, ... 3	22	8	10
Nov. 3	Last day of week,			
" 6	Leave for their Vacation,			
	There remains therefore in this division:—1st. Three free days in case of bad weather; one after each survey. 2nd. Two days at the end of the year, the 4th and 5th November. Total five free day.			
	Total of the days employed 279 + 5 days free,	284		

EMPLOYMENT OF TIME FOR THE YEAR 1851—1852.

Month and Date.	First Division. Second Year's Instruction.	Number of Attendances.	Number of Lectures before Work.	Number of Total of Lectures.
	Brought forward,.	284	.....	.....
December 6	Laying down the First Survey by Reconnaissance, ...	8	.....	.....
" 16	Attack and Defence :—Plate, Batteries, with Plan and Sections of Detail, ...	4	5	6
" 20	Ditto, { Plate 1 ..... 25 / Journal, ... 2 / Plate 2 ..... 13 }	40	6	22
January				
February 7	Designs and Constructions of Revetments, Arches, &c., ...	9	9	9
" 18	Project and Permanent Fortification in Hilly Ground, { Plate 1 ..... 19 / Memoir, ... 3 / Plate 2 ..... 8 }	30	8	19
	SPECIAL WORKS.			
	ARTILLERY. / ENGINEERS.			
March 25	Measurement and Drawings of a Cannon, ... 12 / Project of Fortification in hilly ground, Plate 2 *cont.*, ... 12	12	.....	.....
April 8	Measurement of a Workshop, ... / Out-of-door Work, ...	9	30	30
" 19	Laying down the Measurement, ... 98 / Laying down the Measurement, ... 24			
May 18	Project of Fortification in hilly ground, Plate 3, 14			
" 24	Project for Machines, ... 14			
June 4	Abstracting and calculating Measurements, ... 3			
" 8	Plate 4, ... 11			
" 9	Questions in Artillery, ... 5	97	2	2
	1st. Measurement of *Matériel*, Gun Carriages, &c., 8 / Register of the removal of Earth, ... 3			
	Laying down ditto, ... 10 / Estimate, ... 2			
	Memoir, ... 2			
	Project for Improvements, { Plate 1 .... 30 / Plate 2 .... 6 / Memoir, ... 2 }			
July 6	2nd. Measurement of *Matériel*, ... 8			
" 15	Project for a Cannon, ... 24 / 97			
August 12	Second Reconnaissance Survey, ...	.....	.....	.....
	Out-of-door Work and Tracing of the Lines on the Reconnaissance Plan, ...	7	.....	.....
	One day free in case of bad weather, ...	1	.....	.....
" 21	Geodetical Calculations, ...	4	.....	.....
" 26	Laying down the Reconnaissance Survey, ...	8	.....	.....
September 4	Memoir on Entrenched Lines, ...	1	.....	.....
" 6	Tracing or laying out Camps, ...	1	.....	.....
" 7	Operations of a Sham Siege, ...	13	.....	.....
	One day free, ...	1	.....	.....
" 19	Preparing for the Examination, ...	.....	.....	.....
October				
November 1	Examination for leaving, ...	.....	.....	.....
	Total of the days employed, 323 + 7 days free.	529		

FINAL EXAMINATION.

About six weeks of free or voluntary study is allowed, immediately prior to the Final Examination, for the sub-lieutenants to prepare for their last effort.

The examination which takes place prior to their leaving the School of Application, is entirely conducted by a board of six officers, under the presidency of a general officer alternately of the artillery or engineers, the remaining members of the board consisting of a general officer of each corps and three field officers of these corps; the last three being specially charged with the duty of examining. It takes place in a room set apart for the purpose, with a small interior room in connection with it, into which the members of the board retire to deliberate at the end of each student's examination. The jury assembles each year at the period fixed by the minister of war.

The three examining members conduct the examination of the students in three different branches of study; the first more particularly relating to artillery science, the second to engineering science, and the third to mechanical science in its connection with the art of war. The whole of the students who are to leave the school are first examined in such one or other of these branches of study as may be determined on.

The student under examination is specially questioned by the examining officer in his subject, and occasionally by the president or any other member of the board that may wish to do so, for three-quarters of an hour. As soon as the examination of the student has been concluded, the board retire to the adjoining room and compare their notes of the credits they have severally awarded to the student under examination, and they also examine his drawings, sketches, and memoirs relating to the subjects on which he has been questioned, and prepared during his two years of residence in the school. They severally note the credits to which they consider him to be entitled for them, and adopt the general mean.

As soon as the examination of the whole of the students in this particular study has been finished, the examination in the next branch is commenced, so that five or six days elapse between the first and second examinations of the same student; and the same interval of time occurs between the second and third examinations.

The credit allotted to each student by the board of examiners represents, on the scale of 0 to 20, the manner in which he has replied to the questions, or executed the drawings, sketches, memoirs, &c., belonging to each course. The importance attached to each particular branch of study is estimated very nearly by the amount of time allowed for its execution divided by 20; and the definitive marks which each student obtains for that branch of study is obtained from the products of the numbers respectively repre-

senting the credit for answering, and that for the importance of the subjects on which he has been examined.

The final classification of the order of merit, in each arm of the service, is arranged after a comparison of the total of the marks obtained by each student. This total is the sum of the definitive marks gained by each student in the sciences bearing on artillery, engineering, and mechanics in connection with the art of war, for the talent displayed in drawing, sketching, and writing memoirs, and for skill in practical exercises, as determined by the results of the examination conducted by the jury of examiners, added to the marks due to the previous classification in the school, with the weight or influence equal to one-third of that allowed for the examination by the jury.

The co-efficients of influence for the present year are—

For those particularly relating to Artillery Science,.....	39.29
" " " Engineering Science,...	53.75
" " " Mechanical Science,....	43.00
For talent in drawing, sketching, writing memoirs, &c.,...	6.80
For practical exercises,.....	16.75
Previous classification in the school,.....	45.30

So that the examination conducted by the jury of examiners exercises an influence on the position of the students very nearly approaching to two-thirds of the whole amount.

It is this final classification which determines their seniority in the respective services. We were permitted to be present during the examination, which was entirely oral, of two of the *sous-lieutenants*, before the jury of examiners.

The questions were replied to with great fluency and readiness, but it seemed to us that the examination was somewhat limited for the object in view, viz., that of awarding a credit representing the progress which each student had made in the particular science on which he had been questioned, especially as that credit would have very great weight in determining the candidate's future position.*

On quitting the School of Application at Metz, the sub-lieutenants of artillery and engineers respectively join the regiments, to which they are then definitely assigned as second lieutenants, and continue to be employed in doing duty, and in receiving practical instruction with them, until they are promoted.

* The examination chamber is a small room in the school buildings, near the library, ornamented with portraits of Vauban, and of D'Argenson, under whose ministry the original schools at La Fère and Mézières were founded. At a large table under these portraits, and extending across the room, General Morin, President, and four officers, members of the jury, were seated. The sixth member sat at a small table in front, near the blackboard, at which the student stood. The Commandant, the Director of Studies, and the other officers of the school were seated also in this part of the room.

The student who was first examined was questioned partly by the examiner, partly by the

SUBSEQUENT INSTRUCTION AND EMPLOYMENT.

The lieutenants of the artillery are employed on all duties that will tend to make them efficient artillery officers, and fully acquainted with all details connected with the drill, practice, and manœuvres of the artillery, and also with the interior economy and discipline of a regiment of artillery.

After the officers of artillery are promoted to the rank of second captain, but not before, they are detached from their regiments and successively sent into the various arsenals, cannon foundries, powder mills, and small arm manufactories, pyrotechnic establishments, and workshops, in order that they may become practically acquainted with the whole of the processes connected with the manufacture and supply of artillery, rockets, small arms, powder, material of all kinds, tools, &c., and also with the construction and repair of the buildings and factories required for these purposes. Sometimes they are employed as assistants in these establishments. The inspectors of the arms of regiments are selected from among those who have become acquainted with the manufacture of small arms.

When promoted to first captains they again rejoin their regiments, so that they may not lose the qualifications and knowledge required from a good practical artillery officer.

Field-officers of artillery are employed as superintendents and directors, and captains as sub-directors, of the important works intrusted to their arm.

In time of war, the officers of artillery have the construction of their own batteries, and the direction of the ordnance in battles and sieges, together with the formation of movable bridges and passages by boats.

It must be noticed, in contradistinction to the practice which prevails in England, that the artillery and engineer services manufacture their own tools.

The young engineer officers are employed with the men of their regiments, and with them pass through courses of practical instruction in the field, in sapping, mining, field fortification, sham-sieges,

president, and gave his answers, working problems and drawing illustrations on the board as he went on. He was asked questions as to the details of the steam-engine, and as to the method of casting cannon. The German teacher of the School put him on to construe from a German book, and tried him in speaking; he succeeded just passably in both. The whole occupied about three-quarters of an hour.

The second student, after answering similar scientific questions, had opportunity given him to show his knowledge, which was considerable, of the geology of the neighborhood; and having lived in foreign countries, he was able to make a very good display of his knowledge of German, Spanish, Italian, and English.

After each examination the jury retired into the inner cabinet, by a door opening to it from behind their seats.

bridges, and castrametation. During this practical instruction one of the lieutenants belonging to each company is always present, and the captain of the company visits the work once in the course of the day.

The duties of the officers of engineers in time of peace are the construction, preservation, and repairs of fortresses and military buildings, and the command and instruction of the engineer soldiers.

In time of war, the officers of engineers are intrusted with the construction of works of permanent fortification, of the general works in the attack and defense of fortresses, and the reconnaissance connected therewith.

They *may* also be charged—

With the construction of such works of field fortifications as the commander-in-chief or the generals of division consider necessary; such as *épaulments*, trenches, redoubts, forts, blockhouses, bridge-heads, intrenched camps, as well as the opening of communications, the establishment of bridges resting on fixed supports, and the formation and destruction of roads.

After the officers of engineers have been promoted to the rank of second captain, and not before, they are mostly employed apart from their regiments, on the *état major* of the engineers in fortified towns and places, either in charge of the existing military buildings and fortifications, or with the duty of carrying on, or assisting to carry on, such new works as are in course of construction from time to time.

We have already stated that by the law in France one-third of the officers of the army is obtained from the military schools; one-third from the non-commissioned officers who have been raised to that grade from the ranks; while the remaining third is placed at the disposal of the supreme executive power. As regards the artillery and engineers this last third is in actual practice obtained, like the first third part, from the Polytechnic School, so that only one-third of the officers of those arms are promoted from among the non-commissioned officers, and these seldom rise above the rank of captain. Much attention is, however, paid to the improvement of the education of these latter officers, and we found that *four* officers of engineers and *one* officer of artillery so promoted were, by order of the minister of war, on the recommendation of the inspectors-general, passing through the School of Application at Metz, the course of instruction for them being modified on their account. And it was confidently expected that a large number of those officers who

had been promoted in this way during the war would be ordered to the School of Application at Metz.

We should not omit to mention that occasional exchanges of service take place, during the first year of residence at Metz, among the pupils destined for the artillery, and those destined for the engineers.

The pay of officers of the artillery and of the engineers is the same. A small additional allowance is granted to officers of artillery when mounted.

ARTILLERY REGIMENTAL SCHOOLS.

There are ten regimental artillery schools established in places or towns that are usually garrisoned by the troops of this arm, and one of these schools exists at Metz.

ENGINEER REGIMENTAL SCHOOLS.

The soldiers of the engineers appear to be very well taught in their regimental schools, of which there are three, one for each regiment, established at Metz, Arras, and Montpellier, where the regiments are usually in garrison. The strength of each regiment is 4,500 men.

The instruction given in these schools has for its object to afford, to its full extent, to the officers, *sous-officiers*, and soldiers of the engineers, the requisite theoretical and practical knowledge to enable them satisfactorily to fulfill the duties of their various ranks, and to qualify them for promotion to higher rank.

It is so regulated that at the end of the first year the men have learnt the nature of the service and duties of a soldier; and that at the close of the second year, the practiced sapper is cognizant of mining, and the practical miner is acquainted with sapping.

In the lowest classes the men begin with learning to read and write; this if followed by arithmetic, grammar, writing from dictation, and composition. The next subjects are special mathematics, landscape, plan, topographical and architectural drawing. We attended a class in which a corporal of sappers was explaining to the mathematical teacher (a civilian) the theory of the inclined plane, and we saw a large number of their drawings, topographical and architectural, many of which were very well executed.

The theoretical instruction is given between the months of November and March, the practical instruction in the field, (already noticed) occupies the rest of the year. The combined courses are completed in two years.

REGULATIONS AND PROGRAMMES OF INSTRUCTION

OF THE

IMPERIAL SCHOOL OF APPLICATION FOR THE ARTILLERY AND ENGINEERS AT METZ.

(Abridged.)

I. POLICE REGULATIONS.

THE chief Regulations for the Police of the Establishment are as follows:—

I. BARRACKS.—The Students are lodged in Barracks in the School, under the command of a Captain of the Staff, with the title of Commandant of the Quarter. They take their meals, however, out of the Barracks, in the town. They are allowed free egress and ingress from and to their Barracks, from the call at 6 in the morning to 10 at night, excepting during the hours devoted to lectures and the studies in the rooms. During these hours they must give special notice of their times of going out and coming in.

II. ORGANIZATION INTO BRIGADES AND SECTIONS.—Each Division is arranged in Brigades of thirty Students at the utmost, and each Brigade in two sections. The Students of Artillery and those of the Engineers constitute, as far as possible, separate Brigades. A Captain of the Staff is attached to each Brigade for its superintendence. The students in these Brigades and Sections are arranged in the order of merit which they held on entrance, and the first Student on the list of each Brigade and of each section of a Brigade is called its Chief. This arrangement is preserved at their messes, which are held at the Restaurateurs', each section of fifteen having its own table, and its chief being the head of the mess. Private bills or private additions to the mess are forbidden, the maximum price for the daily fare being fixed by the Commandant of the School.

III. CONDUCT OF THE STUDENTS.—All games of chance are forbidden; and any debts discovered are punished. If a Student continues long without paying such, he is reported to the Minister of War.

IV. INSPECTION OF WORK DONE WITHIN THE HOUSE.—No work or drawing may be done out of the rooms of study, except in cases of illness.

All works to be executed by the Students are considered as service ordered to be done, which must be completed at the hours and within the period fixed in the order of the day. Students who are in arrears of work at the end of their first year are required to finish them during the time of vacation.

V. SUPERINTENDENCE OF OUT-OF-DOOR WORK.—After describing facilities afforded to the Students for working in the country, and stating minutely the method to be followed, the directions add that "on bringing back their plans, Students must present their sketches, and all the notes taken by them, in their rough state, to the Officer of the Staff intrusted to inspect them. They can not begin to put their work into shape till this Officer's visa has been affixed to the sketches, notes," &c.

VI. VACATION.—There is one vacation at the end of the first year. Any class, or any single student, under punishment, may be deprived of this. Any work to which the Professor gives a mark below 7, must be considered incomplete, and to be done again. Students are kept up in vacation to finish their work; but if it is done within fifteen days, and marked by the Professor's visa, they are allowed to go away for the rest of the vacation.

Young Officers, after their final examination, are subject to all the Regulations of the School, down to the moment of their leaving the town.

II. REGULATIONS FOR ESTIMATING THE VALUE OF THE WORK EXECUTED.

The time devoted to each of the courses in the School, to the works of every kind which belong to it, to the exercises, drill, theoretical instructions, &c., is fixed in accordance with programmes approved by the Minister of War; and the Table similar to that given at pages 180—181, exhibiting the employment, is each year submitted for his approbation by the Superior Council of the School.

Every kind of work, such as the out-door operations, sketches, drawings, memoirs, calculations, interrogations, manipulations, manœuvres, drill, &c., is valued by the Professor or Officer of the Staff charged with its direction, by the product of two numbers, one representing the merit of its execution, and the other the importance of the work.

The numbers representing the merit of the execution or instruction are regulated by the scale of 0 to 20, as at the Polytechnic School.

The co-efficient of importance is found by dividing the number representing the maximum value allowed for the execution of any work by 20, the maximum credit for merit; and the number representing the maximum value, allowed for the execution of any work has reference to all the circumstances bearing upon its execution. It is regulated by the number of hours appropriated to its execution; and in estimating this number of hours, regard is had, not only to the time occupied in making the drawing, but also to that which is necessary for the calculations, essays, and sketches indispensable to its execution. The lectures are reckoned at one and a half hours, and the sittings in the Halls of Study at four and a half hours.

The number of hours inserted in the Table giving the distribution of the time employed, being insufficient for the composition of the memoirs, specifications, estimates, &c., the value given for this kind of work, of which a great part is performed out of the Halls of Study, is fixed at twice the number of hours inserted in the Table showing the distribution of the time employed.

The interrogations are the subject of a special credit, the maximum being equal to the number of hours devoted to the lectures, multiplied by one and a half hour, the length of each lecture.

The credit given for a work performed outside the school is divided into two parts: one, equal to one-third of the total credit, is in the hands of the Officer charged with the superintendence of the work, who estimates the zeal and aptitude of the student; the other, equal to two-thirds, is applied by the Professor, and given according to the merit of the work.

The sum of the credits, given for work of all kinds in a course of study, forms the maximum credit for the course.

The method of fixing the credit for the execution of works, according to the time devoted to them, is equally applicable to the exercises, practice, and drill.

When the time granted for the execution of any work has expired, the Director of Studies sends this work to the Professor for his examination, who establishes the number or credit, showing its importance, and returns it to the Director of Studies.

Every work which has been finished and examined, is marked by the Professor by a number representing its merit, which number may be fractional.

This is multiplied by the number representing its importance, and the nearest whole number resulting from this product expresses the value of the examined work.

Every unfinished work receives a provisional value, and is then returned to the person executing it, and as soon as it has been completed a second evaluation is made, but only two-thirds of the difference between the first and second evaluations is added to the first; the same principle is applied to the works which have been valued below seven, or to those which have been amended or recommenced.

Every work which has not been executed by the student is marked 0; but the grounds for its non-execution are placed before the Jury of Examination.

In the event of two papers being so similar that it is evident one must have been copied from the other, and that it is not possible to decide which has been copied from the other, both are marked 0.

And on the other hand, if it is proved that there was no complicity between the authors of the two papers, the copied paper is the only one canceled.

At the end of each year's study, the Council of the School makes a classification of the students of the two divisions.

Each of these classifications is formed of the following elements:—

1st. Notes of conduct given by the General commanding and the Colonel Second in Command.

2nd. Notes of appreciation given by the General Commanding, and the Colonel Second in Command, and by the Officers of the Staff of the School.

3rd. Tables of credits given by two Field Officers of the Artillery and Engineers on the theoretical and practical instruction with which they are charged.

4th. Tables of credits given by each Professor for the works of all kinds, interrogations, &c., of his course.

The classification of the first year comprehends all the works, drill, and practice, executed during the first year, which have been valued, as well as the notes of appreciation and of conduct.

The number appropriated to these notes at the end of the first year is equal to the moiety of the total number allowed for the two years of study.

The classification of the students of the second year presents the reunion of the works executed by them since their entrance into the school.

The maximum number of credits appropriated to all the Officers of the Staff, as a note of appreciation, is equal to one-sixth of the total of all the courses taken together.

The same number, divided into two equal parts, is assigned to the notes of appreciation given by the General commanding and the Second in Command.

Lastly, the notes of conduct given by the General commanding and the Second in Command form one-fiftieth of the total value.

For the classification of each division the Director of Studies abstracts into a Table, for each arm, all the elements which should enter into this classification. Below the name of each student are inserted all the credits which belong to him, and the total, reduced in the ratio of the maximum 20, is the definitive number of the classification of each student.

The Director of Studies appends to these Tables a report containing everything which affords a means of estimating the work, the conduct of each

student, the delays, and the causes, &c. In giving the names of the students whose credits are less than 7, he proposes, conformably with the Regulations, the measures that should be taken with regard to them.

The Superior Council of the School being assembled, the different Tables furnished by the Professors and by the Officers of the Staff, as well as those in which they are summed up, are collated, and the list of classifications for each division and for each arm is fixed separately, with the definitive numbers representing the credits.

These classified lists indicate for each arm the new rank of the Students, their rank at admission to the School of Application and of passage to the first division, the sum of the values for the works executed by them, and all the elements which would tend to enable a proper judgment to be formed of their merits and conduct.

The Superior Council adds to it, if there be any necessity for it, notes, exposing the grounds which have contributed to the principal alterations in the relative position of the Student, and points out those whose credit is less than 7, as well as those who by their bad conduct deserve to become the object of exceptional measures.

Examination for Leaving.

Each year the General commanding the School determines by lot, at least one month in advance, the order in which the examinations for the promotions in the Artillery and Engineers are to take place. The Students belonging to the same arm can change among themselves, but eight days after the lots have been drawn the list of the order of examination is definitely closed. The General commanding the School makes known at the same period the order of the examinations and the division of the subjects between these examinations.

The General commanding the School places before the General of Division, President of the Jury of Examination, the following:—

1st. The division of the subjects between the three examinations.

2nd. The order of examination of the Arms, and of the students of each Arm.

3rd. The provisional classification of the students of the first division made by the Superior Council.

4th. The particular reports relating to each student made by the General commanding the School.

5th. The list of the propositions made by the Superior Council and the proceedings of the sitting at which it was agreed to.

6th. The classification of the Students of the second Division.

7th. Tables of questions established for each course.

8th. The abstracts of the sittings of the Superior Council held since the last examination.

The Student Sub-lieutenants are successively examined in all the branches composing the theoretical and practical instruction of the School. The theoretical knowledge is grouped in three series, each of which is the object of a particular trial.

The drill and practice are executed in the presence of the Jury, who cause the command to be given to the Sub-lieutenant, in order to satisfy themselves of the amount of their instruction, and to assign marks of merit to them individually.

The subjects of the three examinations are divided in the following manner:

First. Examination, made by the Field Officer of Artillery in the—

Course of Military Art.
Course of Artillery.
Course of Veterinary Art.
Sham Siege (part relating to Artillery.)
Course of Military Law and Administration.

Second. Examination, held by the Field Officer of Engineers.

Course of Permanent Fortification and the Attack and Defense of Places.
Course of Construction.
Sham Siege (part relating to the Engineering.)

Third. Examination, held by the third Examiner, taken either from the Artillery or Engineers, in the—

Course of Mechanics.
Course of Applied Sciences.
Course of Topography and Geodesy.
German Language.

Every Student, on presenting himself before the Examiners, submits for their approbation the drawings and manuscripts relating to the subjects on which the examination is to bear. Independent of the questions which are placed before him by the Examiners, the Student Sub-lieutenant must reply to any objections or questions which the members of the Jury may think fit to address to him.

The German Master directly questions the Students, if the Jury wish it. The Professors or their Assistants must be present at the examinations relating to their course.

As soon as the examination is ended, the members of the Jury retire to an adjoining room with closed doors, to determine on the amount of marks to be given to the Student examined.

When the trials of all kinds are finished, the Jury proceed to the definitive classification of the Students belonging to each arm. In making this classification, regard is had to the following considerations:—

1st. Each examination has a co-efficient of importance equal to the sum of all the different courses which are included in it.

2nd. The co-efficient of importance for drawing is equal to the $\frac{1}{12}$ of the sum of the co-efficients of the three examinations.

3rd. The co-efficient of importance of the practice, drill, &c., is, as for the courses, the sum of the co-efficients appropriated to the works taught in the School.

By multiplying the co-efficients of importance by the mean number of marks of merit obtained by the Students in the different examinations, the definitive credit which must be assigned to each Student in the Table of Classification is obtained.

The classification of the School enters into the definitive classification for a value equal to one-third of the total number of the three examinations, without comprising the valuation of the drawings; this value is added to the credits determined above.

The Jury give an account of the proceedings of the examinations in a "*procès-verbal*" addressed to the Minister by the General acting as President.

III. PROGRAMME OF THE ARTILLERY COURSE.

FIRST PART.—INTRODUCTION.

Twenty-six Lectures common to Students of both Arms.

First Lecture.—(1.) Definition of the word Artillery. Material, personnel, science. Object and division of the course.

FIRST SECTION.—EFFECTS OF POWDER.

Ideas on the origin of powder and its use in fire-arms; mealed or pulverized powder; powder in grain. General conditions which powder ought to satisfy; action of each of its component parts. Proportion of component parts used in France. *Fulmi-ligneux.*

Considerations on the physical properties of powder. Size of the grains expressed by the number of grains to the gramme. Density of the grains and specific density of the powder; circumstances causing them to vary. Effects of damp upon powder.

Second Lecture.—(2.) Combustion of powder. Different modes of ignition of powder. Research respecting the laws of its combustion, process of observation employed, laws discovered. Influence of the density, the composition, the mode of manufacture, the damp, the tension and temperature of the surrounding gases.

Combustion of the grains of powder. Calculation applied to the spherical grain. The formula is applicable to the irregular grains of ordinary powder.

Calculation of the density of the gases of powder in a fixed space, on the hypothesis of a simultaneous ignition of the grains. Discussion of the formula obtained; influence of the density of the grains, of the duration of their combustion and of the space in which the powder is inclosed.

Inquiry into the rapidity of ignition of charges of powder. Experiments made upon trains of powder, and upon gun-barrels filled with powder. Conclusions drawn from the results obtained.

Third Lecture.—(3.) Calculation of the density of the gases of the powder on the hypothesis of successive ignition.

Results of the application of the formula to charges of a spherical and a truncated form.

Tension of the gases of powder. Impossibility of determining it by considerations of a purely theoretical nature. Experimental solution of this question. Experiments by Rumfort; description of his apparatus. Results obtained. Formula representing them. Observations on these results.

Fourth Lecture.—(4.) Effects of powder in a fixed space.

Hollow projectiles. The readiest bursting of a hollow sphere takes place in the direction of the plane of a great circle. Determination of the minimum bursting charge; law by which this charge varies with the thickness of the envelope. Influence of the fuse-hole of hollow projectiles; weakening of the envelope of the shell, diminution of the charge; loss of gas, increase of the charge. Effects of the shock of the exploding gases; means of estimating it. Influence of the vivacity of the powder in burning. Number and rapidity of the explosions.

Hollow cylinders burst more easily longitudinally than transversely. Conse-

quences of this principle relatively to the employment of a fibrous metal for the manufacture of arms. Thickness necessary to resist bursting.

Fifth Lecture.—(5.) Effects of powder in cannon.

Analytical theory of the effects of powder in cannon.

Equation of the problem. General expressions of the quantity of force exercised by the expansion of the gases,—of the density of the different sections of gas and of their tension. Differential equations of the motion of the gases, of the projectile, and of the gun. Equation of condition leading to the establishment of the general formula which determines the position of a stratum of gas in the terms of the function of its original position, and of the other data of the question. General relations between the velocity of the projectile and that of the gun.

Density of the stratum of gas at a given moment. Position of the stratum which has a maximum density.

Sixth Lecture.—(6.) Approximative solution applicable to the cases ordinarily met with in practice. Hypothesis relating to the velocity and the tension of different strata of gas.

Relations between the velocity of the projectile and that of the gun. Approximate expression of the amount of force due to the expansion of the gases; line to be followed in the execution of the arithmetical calculations. Formula serving to determine the velocity of the projectile. General considerations on the state of the gases of powder during the burning of the charge. Influence of the motions of the projectile and of the bottom of the bore on the distribution of the gases at each instant. Influence of the successive generation of the gases combined with the enlargement of the space which incloses them on their density throughout the whole duration of the phenomenon.

Seventh Lecture.—(7.) Influence of the vent and of the windage of the projectile on the effects of powder in cannon.

Determination of the loss of velocity occasioned by the windage of the projectile. Influence of the weight of the piece upon the velocity of the projectile. Influence of the weight of the projectile on tension of the gases and upon the velocities of the two bodies set in motion. Influence of the weight of the charge of powder. Charge giving the maximum of velocity. Influence of the size and density of the grains of the powder as well as other circumstances which cause a variation in the law of generation of the gases. Advantage of very rapid combustion in short pieces and of slower combustion in long ones.

Eighth Lecture.—(8.) Influence of the length of bore; circumstances which modify it; length corresponding to the maximum of velocity. Comparison of the quantities of motion of the projectile and of the gun. Trial of a formula fitted to represent their relation. Determination of this relation with the help of the balistic pendulum.

Mean pressure exercised on the projectile during its passage through the bore. Injuries produced in guns by firing; enlargement of metal and cracks; lodgment and percussion of the projectile.

Different effects of the percussion; means tried to prevent injuries (in general.) Considerations on the metals employed in the manufacture of ordnance. Charging with elongated cartridge; use of wooden bottoms and wads.

Ninth Lecture.—(9.) Examination of the proper means for measuring the effects of powder. Eprouvettes of different sorts. Experimental processes

founded on the measure of the velocity of the projectile. Grobert's rotatory machine. Process of Colonel Debooz. Process based on the employment of an electric current. Method by ranges (mentioned here by way of note.)

Balistic pendulum. Pendulum of Robins, of d'Arcy, of Hutton. Improvements introduced in France into the construction of these apparatus. Description of the pendulums in use at the present day; cannon pendulum; musket pendulum.

Tenth Lecture.—(10.) Analytical theory of the balistic pendulum.

1. Receiver pendulum; formula which gives the velocity of the projectile. Determination of the elements which enter into the formula, and the degree of approximation necessary. Simplification of the calculation of the velocities in the case of firing several times consecutively.
2. Cannon pendulum. Amount of recoil in the gun. Percussion of the knife-edges of the pendulum. Case where there is none. Means of correcting the position of the center of percussion.

Eleventh Lecture.—(11.) Examination of the effects of the recoil upon guns and their carriages. The question may be considered as resolving itself into two others.

1. Percussions of the carriage upon the points supporting it; analytical solution. Determination of the percussions and of the force of the recoil in the case of carriages on wheels, and that of mortar beds. Graphic solution of the same question by an analysis of the force which acts upon the bottom of the bore. Modification of the sketch according to the different cases presented by the direction of fire relatively to the ground.

Twelfth Lecture.—(12.) Discussion of points relating to the percussion of the carriage upon its supports, and to the force of the recoil. Influence of the elevation of the line of fire; of the inclination of the ground or of the platform; of the length of the carriage in proportion to its height and of the friction which results from the contact of the trail with the ground. Velocity of recoil of the collective apparatus. Determination of the extent of the recoil on a given ground. Recoil of the different pieces of ordnance in use. Case in which the forepart of the carriage has a tendency to be lifted up; velocity of this motion; determination of the effect resulting from it.

Thirteenth Lecture.—(13.)

2. Percussions produced by the gun upon its carriage. Determination of the amount of percussion of the breech upon the elevating screw, and of that of the trunnions upon the trunnion holes. Discussion of points relative to the effects produced. Influence of the elevation; of the dimensions of the gun, and of the proportion of its weight to that of the entire apparatus.

Effect of the elasticity of the different parts of the apparatus. It diminishes the wear of the parts struck, and renders it necessary to take into account the velocity of the parts striking.

Fourteenth Lecture.—(14.) Effects of powder in mines. Historical notices. Dimensions of the boxes containing the powder. Considerations on the effects of the expansion of the gases in an indefinite or limited compressible medium.

Definitions having reference to craters and chambers of mines. Ordinary charge of the chamber. The old rule for miners; its entire alteration. Table

relating to different kinds of medium. Overcharged chamber. Overcharged chamber or "camouflet." Limit of the effects of compression which result from the action of the chambers. Use of gun cotton. Considerations on the effects of the petard. Dimensions of the cavity reserved for the powder. Means employed or proposed to diminish the charge of powder proportioned to a given effect.

SECOND SECTION.—MOTION OF PROJECTILES IN SPACE.

Fifteenth Lecture.—(15.) Science of projectiles. Historical notices. Utility of an acquaintance with the laws of the motion of projectiles in a vacuum. Definitions relating to the trajectory. Differential equations of the motion in vacuo. Equation of the trajectory. Inclination of its elements. Velocity of the projectile at any one point. Duration of its passage. Determination of the range and of the angle of greatest range. Relations between the ranges; the initial velocities; and the angles of projection. Examination of the cases where the theory of the parabola is applicable.

Preliminary ideas on the resistance of fluids; difficulties inherent in this question. Approximative formula of the resistance, established by the help of the principle of active forces; circumstances not taken into consideration by it.

Sixteenth Lecture.—(16.) Experiments relating to the determination of the resistance of the air.

1. Case of small velocities. Rotatory apparatus; results furnished by them in the case of thin planes; their essential defect. Apparatus with rectilinear movement. Mean value of the co-efficient of the theoretical resistance in the case of thin planes; modification of this value for the case of spheres, &c.
2. Case of great velocities. Direct determination of the resistance of the air by the aid of the balistic pendulum. Experiments of Hutton, their results. Experiments made at Metz in 1839 and 1840. General expression of the resistance based upon the total of the results obtained, and containing a function of the velocity in three terms. Search after a function in two terms fit to replace in each particular case the general expression.

Seventeenth Lecture.—(17.) Theory of the motion of projectiles in the air. Differential equations of the motion. Hypothesis on the relation of the element of the trajectory to its projection. Calculations based on this hypothesis, and leading to the final equation of the arc of the trajectory. Inclination of the element of the trajectory. Velocity of the projectile at a given point. Duration of the passage.

Eighteenth Lecture.—(18.) Examination of the functions employed in the formulas of the science of projectiles. Formation of the balistic co-efficient, and the series contained in the functions. Relations of the series and the functions to each other. Arithmetical tables designed to give their values. Determination of the relation of an arc of the trajectory to its projection. Error resulting from the introduction of the constant relation in balistic calculations.

Nineteenth Lecture.—(19.) Application of balistic theories to the movement of projectiles thrown at great angles. Analysis of the trajectory, and determination of all the circumstances of the movement. Trajectory of shells considered as a single arc. Solution of several problems involved in this hypothesis. Determination of the range. Velocity corresponding to a given range

and angle of projection. Angle of projection corresponding to a known initial velocity and range. Angle of greatest range. Variation of the velocity of the projectile during the whole of its passage. Limit of velocity of projectiles falling vertically in the air.

Twentieth Lecture.—(20.) Application of balistic theories to the motion of projectiles thrown at low angles. Case where the relation of the arc to its projection can be supposed sensibly equal to unity. Problems relative to direct fire; distinction established between the angle of projection and the angle of fire. In ordinary cases in practice the angle of fire is very nearly independent of the height of the object aimed at. Relations between the angle of projection, the angle of elevation of the object aimed at, and the angle of descent. Problems relating to plunging fire. (Ricochet fire.) Determination of the initial velocity and the angle of projection for a projectile which has to pass, firstly, through two given points; secondly, through one given point, the trajectory having at this point a known direction. Case of practical impossibility.

Twenty-first Lecture.—(21.) Relations between the velocities, the spaces traversed, and the durations of passage in the rectilinear movement of projectiles. They are applicable to direct fire, and are independent of the function of the velocity which enters into the expression of the resistance of the air. Case where the resistance of the air can be supposed proportional to the square of the velocity. Establishment of balistic formulas in this hypothesis. Application of the formulas to the resolution of one of the problems connected with a plunging fire. Comparison of the results obtained with those arrived at by the use of general formulas. Indication of methods applicable to the resolution of several questions in projectiles.

Twenty-second Lecture.—(22.) Examination of disturbing causes which influence the motion of projectiles.

1. Disturbing causes acting on the projectile during its passage through the bore. Imperfections of form, such as want of straightness in the bore, faulty position of the line of sight and the trunnions.

   Influence of the windage of the projectile and of the percussions which result from it. Deviation from the original direction; its consequence in the different kinds of fire. Effect of the recoil and the vibrations of the barrel in the fire of small-arms.

   Influence of the various causes which are capable of modifying the initial velocity.

2. Disturbing causes acting upon the projectile during its passage through the air. Influence of the rotatory motion which results from the last percussion within the bore. Effects of the eccentricity of projectiles. Case where the rotation occasions no deviation. Influence of the proximity of the ground. Deviation produced by the wind (air in motion.) Influence of atmospheric changes.

THIRD SECTION.—MOTION OF CARRIAGES.

Twenty-third Lecture.—(23.) Importance of the question. Preliminary ideas. Resistance due to the motion of a carriage and determination of the effort necessary for drawing it in the case of uniform motion. Two-wheeled carriage on level ground; the effort of draught in a direction parallel to the ground; first, resistance referable to the friction of the wheels on the axle; secondly, resistance referable to their revolution upon the ground. Influence of the weight of

the carriage. Advantage of large wheels over small ones, demonstrated in the two cases of a yielding soil and a hard soil scattered over with obstacles. Expression of the power of draught necessary to overcome the two resistances united.

Twenty-fourth Lecture.—(24.) General expressions of the effort of draught necessary for two-wheeled and four-wheeled carriages; case of a locked wheel. Influence of the direction of the traces and of the inclination of the ground upon the draught. Advantage of rolling over dragging for the transport of burdens. Examination of resistances which are developed in the passage from repose to motion. Considerations on the position of the fillet in the box, and determination of the co-efficient of friction for the case of the revolution of the wheel about the axle.

Influence of the length of the nave on the frictions when the axle is thrown out of a horizontal position.

Twenty-fifth Lecture.—(25.) Turning of carriages considered successively in the case of two-wheeled and four-wheeled carriages. Center and angle of the turn in four-wheeled carriages. Calculations of the angle of the turn and of the space required by the carriage to execute a half turn. Examination of the dimensions of the carriage which influence the angle of the turn. Diameter of the fore-wheels and height of the body of the carriage; distance between the wheels and breadth of the body of the carriage; position of the point of reunion of its fore and hind parts. Examination of the circumstances favorable or unfavorable to the action of the horse. Relation between the forces to which he is subjected, and the pressure of his feet on the ground. Sliding of the feet; influence of the weight of the animal; of the co-efficient of friction; and of the direction of the traces. Lifting of the fore-hand; influence of the weight of the horse, and of the increased distance between the points on which he rests; of the position of his center of gravity; and of the direction of the traces.

Twenty-sixth Lecture.—(26.) Considerations on the mode of action of the draught-horse. Effect of his weight, and of the inclination of the traces. Effort of draught of which the horse is capable, both momentarily and continuously; results of experiments. Composition of artillery harness. Harness à limonière (with shafts and cross-bar,) or on the French system; on the German system, with pole and support. Use and discontinuance of swing bars. Arrangement of the traces. General arrangement of harness. Bât-saddle.

SECOND PART.

CLASSIFIED ACCOUNT OF SMALL ARMS AND OF ARTILLERY MATERIAL.

Twenty Lectures, of which Fourteen are common to the Students of both Arms and Six confined to Artillery Students.

FIRST SECTION.—SMALL ARMS.

Twenty-seventh Lecture.—(1.) Classification of small arms. Arms not fire-arms. Classification of hand-weapons. Considerations on the profile and outline of cutting weapons. Effect of the curve. Division of the mass. Form of the hilt.

Considerations on the profile and outline of thrusting weapons.

Position of the center of gravity; form of the point. Description of arms other than fire-arms now in use. Sabres and swords. General ideas respecting their component parts; blade, hilt, and scabbard. Regimental arms. Infantry sword. Sword-bayonet of the artillery and chasseurs, cavalry sword; peculiar requisites. Sword of cavalry of reserve, of cavalry of the line, and of light cavalry. Horse artillery sword.

Officers' and non-commissioned officers' arms. Cavalry lance. Camping axe. Side-arms in use in the navy. Sword, pike, boarding-axe, dirk.

Defensive armor. Cuirassiers and carabineers' cuirasses. Cuirass and helmet of the sapper.

Twenty-eighth Lecture.—(2.) Fire-arms. Historical notices. First attempts in fire-arms. Hand cannons. Arquebuses, culverines, &c. Poitrinal, match-lock, firelock, pistol, and blunderbuss.

Means employed successively for loading and ignition of the charge. Twisted match, wheel-lock, flint-lock, percussion-lock, (the two last mentioned here by way of note.) Classified account of fire-arms now in use. Muskets. Considerations on the weight and principal dimensions of muskets. Detailed description of the infantry musket. Action of the flint and the percussion lock.

Twenty-ninth Lecture.—(3.) Comparison of the flint and the percussion musket. Voltigeur's, dragoon's, and double-barreled musket. Gendarmerie and cavalry carbine. Cavalry and gendarmerie pistol. Arms in which precision of aim is studied. Means employed to prevent the deviations caused by the windage of the projectiles and their rotatory movement in the air. Diminution and suppression of the windage; straight grooves in the barrel, spiral grooves, rifled arms. Rotation of the ball about its axis of flight.

Principles of arrangement of rifled arms. Charge of powder and inclination of the grooves; two modes of solution, powerful charge and long spiral, weak charge and short spiral. Length of the barrel: conditions which determine it; number and form of the grooves.

Thirtieth Lecture.—(4.) Loading of rifled arms; ramming the ball home; loading at the breech. Different methods tried. Loading with a flattened ball; effect of the flattening of the ball. Examination of the successive improvements to which this idea has served as a basis. Chambered arms; use of the short bottom and the patch. Arms *à tige*. Elongation of the ball; shortening of the spiral groove; diminution of the charge; advantages resulting from it. Pointed cylindrical ball; principles of its outline; effect of the notches of the ball; superiority of this projectile over the spherical balls. Summary examination of the different models of rifled arms which have been successively in use. Versailles rifles.

Wall-piece, pattern 1831. Common rifle, pattern 1842. Wall-piece, pattern 1840. Bored-up wall-piece, pattern 1842. Pistols for officers of cavalry and gendarmerie. Rifles *à tige*, pattern 1846, and artillery carbine *à tige*. Description of these two arms. Superiority of the rifle *à tige* over the arms for precise aim previously adopted. Trial relating to a new improvement in the construction of rifled arms. Disuse of the "*tige*." Ball with cup. Comparative notice of the fire-arms of the different European powers.

SECOND SECTION.—PROJECTILES AND CANNON.

Thirty-first Lecture.—(5.) Principles of construction of projectiles.

Considerations on the substances which may be chosen for the manufacture

of projectiles. Essential conditions, density, hardness, tenacity, cheapness. Projectiles of stone, lead, cast-iron, iron, copper, gun-metal. Forms of projectiles.

Exterior form; conditions which serve to determine it. The spherical form preferable to any other in the actual state of artillery. Advantage of elongated projectiles. Conditions relating to their use. First attempts. Interior form of hollow projectiles; howitzer shells, bombs, and grenades. Thickness of the metal; fuse-hole; charging-hole of naval hollow projectiles; lugs or handles of shells. Density of projectiles. Recapitulation of the balls; howitzer shells; shells and grenades in use, their nomenclature, dimensions, weight. Cannon-balls. Choice of metal and weights. Different arrangements for the use of shot, case-shot, canister or naval grape-shot. Spherical case; conditions relating to their use. Charge of spherical case. Bar-shot. Rescue shells.

Thirty-second Lecture.—(6.) Cannon. Historical ideas on the subject. Principle of arrangement of ancient arms and machines of war. Motive force employed; its inferiority compared to that furnished by the combustion of powder. Earliest cannon.

Historical view of the different systems of ordnance which have been successively in use in France.

1. Cannon. Calibres in use in the 16th century. Edict of Blois, 1572. Cannon employed in the reign of Louis XIV. Regulation of 1732. System of Vallière. Modifications introduced by Gribeauval in 1765. Cannon of the year XI. Cannon in use at the present day.

2. Ordnance adapted to hollow projectiles. Difficulties inseparable from the throwing of hollow projectiles; first attempts. Mortars. Double fire. Ancient calibres. Mortars in use at the present day. Stone mortar. Howitzers, their first use in the French artillery; howitzers of 1765; of the year XI. Calibres in use at the present day. Considerations on the calibres of different kinds of cannon. Siege, garrison, field, coast, and naval ordnance. Siege, garrison, field, mountain, coast, and naval howitzers. Mortars and stone mortars. Considerations on the metals which may be employed in the manufacture of cannon for siege, garrison, field, coast, and naval purposes. Interior form of ordnance.

1. Part of the bore traversed by the projectile, transverse section; trial of rifled cannon, longitudinal section.
2. Part of the bore occupied by the charge; influence of its form; the spherical, cylindrical, truncated form. Chambers of mortars; reason for their adoption. Cylindrical and truncated chambers; comparison of their effects. Spherical chamber; pyriform chamber: interior form of the naval mortar *à semelle* (cast in one piece with the bed.) Chamber of howitzers; experiments with reference to their adoption for field howitzers. Dimension. Howitzers without chamber. Chamber of carronades. Junction of the chambers with the rest of the bore: form of the bottom of the bore or of the chamber.

Thirty-third Lecture.—(7.) Vent; its object, its dimensions. Bushes inserted before casting, (*masses de lumière;*) after casting, (*grains de lumière.*) Considerations on the position of the vent relatively to the charge. Experiments made with the infantry musket, and with 24 and 16 pounder guns.

Arrangement of the vent in guns of 1732; portfire chamber. Vent of mortars. Priming pans. Windage of projectiles; conditions which determine it for the different services. Rules received with respect to ancient guns. Dimen-

sions in use at the present day. Different characteristics resulting from the windage of projectiles. Length of the bore. Question of the length of the bore considered with reference to the projectile effect of the powder. The length of ordnance is determined by considerations unconnected with this effect.

Length of bore of siege and defensive artillery, of field, coast, and naval guns. Length of bore of mortars, and of the stone mortar. Length of bore of howitzers. Thickness of metal and external outline. Cannon:—Theoretical determination of the external outline necessary for resistance to the effect of the gases of the powder. Co-efficient of resistance, its value in the guns in use. Thickness in the chase necessary for resistance to the percussions of the projectile.

Swell or moulding of the muzzle. Thickness at the position occupied by the trunnions. Thickness of metal of the different systems of cannon which have been successively in use in France. Thickness of metal in howitzers. Form resulting from the diminution of internal diameter, at the position occupied by the chamber. Exceptional form of the siege howitzer. Outline of the interior of mortars.

Thirty-fourth Lecture.—(8.) Line of sight; its object and arrangement. Considerations on the inclination of the line of sight relatively to the axis of the gun. Trunnions; object and arrangement of trunnions and their shoulders. Position of trunnions relatively to the center of gravity of the gun. Preponderance of the breech over the chase; manner of estimating it; preponderance allowed in the different guns in use. General principle serving as the basis for its adoption. Position of trunnions relatively to the axis of guns. Reasons for their depression; circumstances which cause it to vary. Trunnions of mortars; their reinforces. Dolphins of ordnance. Weight of ordnance; necessary relation between the weight of a gun, and the quantity of movement of its projectile. Conditions serving to determine the weight of the different species of cannon, howitzers, and mortars in use. Examination of the weights adopted for the pieces of ordnance of all sorts, which have been successively employed. General recapitulation of the different species of ordnance in use. Nomenclature. Dimensions, weight. Land artillery. Siege, garrison, and field guns. Siege, garrison, field, and mountain howitzers, mortars, and stone mortars. Naval artillery. Cannon, carronades, howitzers, mortars, stone mortar, blunderbuss. Observations on ordnance. Exceptional ordnance. Villantroy's howitzers. Belgian mortar of 60 c., &c. Description of the artillery petard.

THIRD SECTION.—WAR AND SIGNAL ROCKETS.

Thirty-fifth Lecture.—(9.) Historical ideas on the subject. Cause of the motion of rockets. Their exterior and interior form. Relation which should exist between the law of generation of the gases and the orifice for their escape. Measure of the tension of the gases in rockets. Results of experiments. Motion of the rocket. Variation of the velocity during its passage. Means of regulating the motion; effect of the directing stick. Influence of the wind upon the trajectory of the rocket.

Description of rockets in use.—1st. War rockets; calibres employed; body of the rocket; arrangement of the stick. Projectiles fitted to the head of the rocket; rockets without stick. 2d. Signal rockets; their calibres and composition.

FOURTH SECTION.—CARRIAGES.

Thirty-sixth Lecture.—(10.) Historical ideas on the subject. Arrangements originally in use for the service of ordnance. Successive improvements. Carriages on wheels. Introduction of limbers. General conditions which gun-carriages should satisfy.

General principles of their construction:—1st. With reference to the act of firing. 2dly. With a view to transport.

Mortar carriages. Particular requisites. Description of the carriages in use. Siege carriages; particular conditions. General arrangement of ancient siege carriages. Detailed description of the present siege carriage and its limber; its weight and different characteristics. Field carriage; particular requisites; general arrangement of the carriages employed before 1765. Field carriages of the system of Gribeauval; its defects. General arrangement and detailed description of the present field carriage and of its limber. Weight and different characteristics. Mountain carriages; particular requisites; description of the carriage and of the arrangement of its shafts (*limonière.*)

Thirty-seventh Lecture.—(11.) Garrison and coast carriages; particular requisites; object of the platform for the two systems; its principal dimensions; position of the pintle or working bolt (*cheville ouvrière.*) General arrangement of ancient garrison and coast gun-carriages. Description of the present garrison carriage; change of the carriage into a movable one on four wheels; weight and different characteristics. Replacement of the platform by a directing transom bed under certain circumstances of the service. Casemate carriage. Iron carriages; inconveniences of this kind of construction for siege purposes and on the field of battle; its advantages for the armament of coasts. Description of the coast carriage actually in use; weight and different characteristics. Naval carriages; particular requisites. General arrangement of naval carriages in use. Carriage on four small wheels for cannon. Bracket carriage (*à échantignolle,*) and carriage with double pivot platform for howitzers. Carronade carriage. Mortar bed, cast in one piece with the mortar, (*à plaque.*) Exceptional methods of construction. Depressing gun carriages for a very plunging fire. Villantroy's howitzer beds, those of the Belgian mortar of 60 c., &c.

FIFTH SECTION.—CARRIAGES AND OTHER PARTS OF AN ARTILLERY TRAIN. ARTILLERY OF FOREIGN POWERS.

Thirty-eighth Lecture.—(12.) Battery carriages. Ammunition wagon. Historical ideas on the subject. Requisites for carriages used for the transport of munitions of war. General arrangement and description of the present ammunition wagon. Principles of arrangement of the ammunition chest. Loading of the chest with munitions of various kinds. Mountain ammunition chest. Loading of the chest with howitzer ammunition and infantry cartridges.

Battery wagon; object of this carriage; patterns successively adopted. Description of the wagon, pattern 1833. Field forge; object of this carriage. Description of the forge in use. Arrangement and play of the bellows. Mountain forge. Description and loading of it.

Thirty-ninth Lecture.—(13.) Park carriages and machines.

Park wagon. General arrangement and description of the park wagon and its limber. Carriages destined to the transport of heavy burdens. Ancient gun wagon. Truck. Block carriage. General arrangement and description

of the carriage. Siege cart; its object and description. Devil carriages. Arrangement of the ancient devil carriages with perch and with screw. Devil carriage with roller. Description of the carriage and of its mechanism. Gin. General arrangement of the different patterns successively employed. Description of the gin at present in use. Handscrew; its use, general arrangement, and description.

Fortieth Lecture.—(14.) Pontoon equipages. Conditions which military pontoon equipages should satisfy. Considerations on the nature of the supports to be employed. Reserve pontoon equipage. Boat of the reserve equipage; its general form and dimensions. Description of the boat and skiff; use of the boat for navigation; its weight and different properties.

Tackle and machines employed for bridge-making. Balks, moorings, chesses, blocks, and balk collar. Framework, with movable head; different kinds of piles. Means of anchorage. Common anchor; its properties. Anchor basket and chest. Buoy. Cordage. Ideas on its arrangement and on the measure of its resistance. Capstan. Windlass. Tackling. Handscrew. Pile driver. Hand rammer. Grapnel and hooks.

General arrangement of the boat carriage. Description. Its weight and properties. Light equipage.

Forty-first Lecture.—(15.) General ideas on the artillery of the different European powers, and comparison with the French material.

Ordnance; description, species, and calibres. Gun-carriages, carriages, and other parts of the train. General arrangement; facility of movement; modes of harnessing, &c.

SIXTH SECTION.—DETAILS OF CONSTRUCTION OF GUN CARRIAGES AND ARTILLERY CARRIAGES, AND MEANS OF PRESERVATION OF MATERIAL.

Forty-second Lecture.—(16.) Knowledge of woods. Preliminary ideas. Structures and general properties of woods. Diseases and defects of woods. Description and properties of the principal substances employed in the construction of the material; uses to which the different kinds of wood are specially destined. Selection of standing timber; felling; transport; reception of woods; cubature. Cutting up in large and small sizes. Observations on the shrinking of wood. Preservation of woods. Drying in the air. Round, squared, and blocked-out timber. Preservation in store; preservation in water. Steeping. Influence of the contact of woods with other woods, and with metals.

Forty-third Lecture.—(17.) General considerations on the substances employed in the manufacture of gun and artillery carriages. Different properties of metals. Choice of kinds of wood; effects of their being dried. Classified account of axles and wheels. Axles; substance employed, their forms and dimensions. Wheels; essential requisites. Importance of the elasticity of wheels. Effects of the dishing of a wheel, form of the spokes, coupling of the spokes with the nave and the felloes. Tires. Form and number of the felloes determined by the effects of the drying. Form of the nave. Wheel-boxes.

Forty-fourth Lecture.—(18.) Means employed for the connection of the pieces which enter into the composition of gun-carriages, carriages, and other furniture of the train. Nails, clinch nails, rivets, bolts, screws, &c. Examination of the joinings employed in the construction of gun-carriages, carriages, and other furniture of the train.

General principles. Joinings of gun-carriages. Joint plates ("*rondelles d'assemblage.*") Mortar beds, siege, field, and garrison carriages.

Forty-fifth Lecture.—(19.) Joining of other carriages and furniture. Hind parts, ammunition wagon, battery wagon, forge, park wagon, block carriage, cart, devil carriage, and drays. Boat and wherry. Fore parts, particular requisites. Fore parts of the field and siege carriage, of the park wagon, devil carriage, and drays. Barrels and cases.

Forty-sixth Lecture.—(20.) Means employed for the preservation of the material. Cost price of the principal parts of the material. Ordnance, projectiles, powder, carriages, and other furniture of the train. Small-arms. Preservation of ordnance in gun-metal and cast-iron. Preservation of projectiles. Formation and counting of piles. Rust-cleaning machine. Preservation of gun-carriages, carriages, and other furniture of the train. Different methods of stacking in use. Preservation of powder and made-up ammunition; stacking in powder magazines. Means proposed for avoiding the danger of explosion. Preservation of small-arms. Armories. Preservation of iron and cut wood.

THIRD PART.

FIRE OF ORDNANCE AND PORTABLE FIRE-ARMS. EFFECTS OF PROJECTILES.

Forty-seventh Lecture.—(1.) Fire of ordnance. Kinds of fire in use with ordnance. Choice of charges of powder. Charges of powder formerly in use; their progressive reduction. Charges of field, siege, garrison, coast, and ships' cannon; of howitzers and mortars.

Arrangement of the charge. Shot cartridge for field guns. Loading of the other kinds of guns, of howitzers, mortars, and the stone mortar. Loading for fire with red-hot shot. Armaments for the service of ordnance. Methods of igniting the charges of powder; tubes formerly in use, friction tubes. Percussion system; Swedish tube. Ignition of the charge of hollow projectiles, fuses of hollow projectiles, fuse with several pipes for the fire of spherical case, hand grenade fuse. Rapidity of fire. Laying of ordnance. Principal methods of laying guns; laying them by the help of the line of sight. Determination of the elevation. Instruments in use to obtain elevations. Negative elevations, means of using them. Laying guns for fire parallel to the ground; for breaching fire at a short distance.

Forty-eighth Lecture.—(2.) Determinations of elevations by experiment; construction of practice tables. Laying guns when the axis of the trunnions is not horizontal. Laying guns with the help of the plumb-line and quadrant; plunging fire, rectification of the aim.

Fire of mortars, means for directing it in use; use of pickets, of the line, of the quadrant. Laying pieces in the case of a defective platform. Means of laying them for night-firing. Laying naval ordnance; use of the front sight. Initial velocities of projectiles with the different charges in use. Angles of sight, and point-blank ranges of ordnance. Ranges at different sights. Maximum ranges.

Forty-ninth Lecture.—(3.) Probabilities in the fire of ordnance; known laws, facts ascertained by experiment. Distribution of projectiles over an object aimed at of indefinite extent. Mean point of impact. Fire of canister; effects of the dispersion.

Fire of spherical case. Effects of the bursting of the projectile; dispersion of the balls and of the explosions. Fire of the stone mortar; use of mortars for the same purpose.

Fire of small arms: charges of powder adopted. Ball cartridge. Initial velocities of balls with the different arms. Angles of sight and point-blank ranges. Rules for fire according to distances, for muskets, carbines, and pistols. Fire of rifled arms; use of the tangent scale. Probability of the fire of small-arms; comparison of arms with smooth-bored and rifled barrels. Different means employed for the estimation of distances.

Fiftieth Lecture.—(4.) Effects of projectiles on the different substances fired at. Effects of concussion and penetration. Effects on earth. Theory of the penetration of a projectile into a resisting medium. Formula to express the penetration, based on the results of calculation and experiment. Effects of penetration into wood. Effects on metals, cast-iron, iron, lead. Effects on masonry and on rock. Application to a breaching fire delivered in a regular direction relatively to the revetment. Effects of the shock of projectiles upon living bodies. Effects of hollow projectiles bursting in different media; earth, wood. Method of bursting employed against troops.

Effects of spherical case. Incendiary effects. Effects of war rockets. Explosive rockets. Incendiary rockets. Effects of concussion.

FOURTH PART.

TRACE AND CONSTRUCTION OF BATTERIES.

Six Lectures, common to the Students of both Arms.

Fifty-first Lecture.—(1.) Definitions. Meaning attached to the word "battery." Different denominations given to batteries: first, according to the circumstances of the war in which they are employed; secondly, according to their mode of construction; thirdly, according to the kind of ordnance with which they are armed; fourthly, according to the kind of fire for which they are intended; fifthly, according to the direction of their fire.

Principles of construction. General considerations on the elements which constitute the different kinds of batteries which have reference to them. Epaulment; its length, height, and thickness in different cases. Section of the epaulment. Ground-plan of the epaulment of the different kinds of batteries; returns at its extremities. Case where the battery is in advance of a parallel. Epaulment with redans; its trace.

Embrasures opened in the epaulment; their construction in different cases; slope of the bottom; interior opening; exterior opening; form of the cheeks.

Genouillère; fixing of its height for the different kinds of fire. Limit of the obliquity of the embrasures.

Fifty-second Lecture.—(2.) *Terre-Plein;* its position relatively to the ground; its length for the different kinds of batteries. Disposition of the part unoccupied by the platforms. Terre-plein of garrison, field, coast, and barbette batteries.

Ditch; cases in which it is employed. Its position with reference to the epaulment. Depth, breadth, section, and plan of the ditch.

Communications between the battery and the works in its neighborhood; parallels or trenches; plan and construction. Communication between the battery and its ditch.

Powder magazines: their object. Discussion respecting their site and capacity with a view to the different kinds of batteries, viz., siege, garrison, and field batteries.

Traverses of *crownwork* and garrison batteries. Width between them and dimensions.

Fifty-third Lecture.—(3.) Details of construction. Different materials employed in the construction of batteries. First, materials for revetments, fascines, gabions, hurdles, sods, bags of earth, withy-bands, stakes, &c. Secondly, materials for platforms; hurtoir, sleepers, planks, beams, pickets. Construction of revetments of different kinds employed in batteries. First, revetment of the interior slope of a battery upon the natural ground. Secondly, revetment in use when the terre-plein is more or less sunken. Ordinary siege battery, battery in a parallel, battery in a crownwork. Third, revetment of the cheeks of embrasures in the different cases met with in practice; direct batteries with point-blank range; ricochet, breaching, garrison, and field batteries.

Fifty-fourth Lecture.—(4.) Construction of platforms. Ordinary siege platforms, movable platforms (*à la Prussienne,*) garrison and coast platforms, ordinary mortar platforms, platforms for coast mortars of great range. Peculiar case where the fire has to be elevated or greatly depressed. Construction of the communications from the battery to the parallel and to its fosse. Construction of powder magazines in batteries. Magazines of siege batteries, Nos. 1, 2, 3, 4. Case of breaching batteries; garrison battery and field battery. Magazines. Degree of resistance offered by blinded magazines. Modifications adopted for the strengthening of magazines whose construction is already fixed.

Fifty-fifth Lecture.—(5.) Number of workmen to be employed on the construction of the different parts of batteries: revetments, platforms, communications, powder magazines. Earthworks.

Duration of the total labor necessary for the construction of each kind of battery. Duration of the duty for the different parts of the *personnel* employed upon the construction; officers, gunners, assistants. Definitive number of workmen necessary for the construction of the different kinds of batteries. Tools of different kinds.

Simultaneous execution. Preliminary operations. Reconnaissance. Prolongations. Sketch of the plan of a battery. Formation of the working party. Transport of materials. Plan of the battery. First, battery having its terre-plein on the level of the ground. Disposition of the working party. Work of the first night, of the following day, of the second night. Second, a battery sunk outside a parallel. Third, battery in a parallel or trench of some kind already established. Day labor, night labor.

(4.) Particular case of crownwork batteries.

Fifty-sixth Lecture.—(6.) Exceptional constructions. Blinded batteries for cannon or howitzers; for mortars. Batteries of earth-bags. Batteries on stony ground, on the rock, or marshy soil. Floating batteries. Construction on sites deficient in space. Case where the fire of the place is too dangerous. Coast batteries. General arrangement.

Instruction preparatory to working at the plans of batteries. (Course.)

FIFTH PART.

UNIFORM ORGANIZATION AND SERVICE OF THE ARTILLERY.

Ten Lectures common to Students of both Arms.

FIRST SECTION.—UNIFORM ORGANIZATION OF THE ARTILLERY.

Fifty-seventh Lecture.—(1.) Historical résumé. Progress of modern artillery, from its origin down to our time. Artillery of Charles VII. and of Louis XI. Progress under Francis I. Effects of the wars of religion. Edict of Blois, 1572. Improvements by Sully. Creation by Gustavus Adolphus. State of the artillery under Louis XIV. Employment of artillery on the field of battle at the commencement of the 18th century. Regulation of 1732. Introduction of howitzers into the French artillery. Regimental pieces. Progress of the artillery in Prussia and in Austria in the Seven Years' War. Reorganization of the French artillery in 1765. Résumé of the improvements owing to Gribeauval. System of the year XI. Present system.

Historical ideas on the personnel of the artillery. State of the personnel at the commencement of the use of fire-arms. Masters and grand-masters of the artillery, &c. Personnel employed originally on the service, and the guard of ordnance. Creation by Louis XIV. Account of the successive modifications in the personnel from this epoch down to 1765. Organization of 1765. Horse artillery. Pontoneers. Artillery train. Artillery of the Imperial Guard. Organization of 1829. Present state of the personnel. Regiments of artillery. Composition of the personnel of the different kinds of batteries. Companies of pontoneers, workmen, armorers, veteran gunners. Driver-corps ("*train de parc.*") Naval artillery.

Fifty-eighth Lecture.—(2.) Committee and central depôt of artillery. Organization of artillery commands Establishments for the instruction of the personnel; artillery schools. Creation in 1679. Present schools; personnel attached to them. Central school of military pyrotechnics. Establishments for the preservation of the material. Importance of the material of artillery. Its state in France at different epochs. Artillery directions. Division of the territory of France. Personnel of the directions.

Establishments for the manufacture of the material. Ideas on the subject of their management. Arsenals; their object, management, number, personnel. Forges; their object, management, districts, personnel, inspection. Foundries for land artillery; their number, management, personnel, inspection. Naval foundries. Manufactures of arms; their special management, number, personnel, inspection. Branch of the service connected with gunpowder and saltpetre. Powder manufactories and refineries; management, personnel. Direction of the service. Establishments existing in France. Percussion cap manufactory.

SECOND SECTION.—SERVICE OF THE ARTILLERY IN THE FIELD. ORGANIZATION OF THE FIELD ARTILLERY TRAIN, ETC.

Selection of ordnance, conditions which determine it; cannon, howitzers, relation between them. Proportion of the number of pieces of ordnance to that of the combatants. Mean proportion received in France; circumstances

which may lead to a modification of it. Organization of ordnance in batteries. Account of the arrangements formerly adopted. Present system. Distribution of the batteries in the army. Principles received. Application of these principles to the artillery train of an army of a given strength. Infantry divisional batteries; cavalry divisional batteries; reserve batteries. Case of the formation of army corps. Composition and supply of batteries. Principles and details of the supply of batteries with ammunition for the guns and for the troops. Second supply distributed amongst the parks.

Fifty-ninth Lecture.—(3.) Field parks. Their composition, in carriages of all kinds. Application of the principles to the artillery train of an army of a given strength. Approximate relation of the number of the carriages and of the horses of the train to that of the pieces of ordnance. Means of renewing the supply of the parks.

Personnel of the field train. Personnel of the batteries; working companies. Companies forming part of the train. Personnel attached to the parks. Staff. Particular conditions, having reference to war in a mountainous country. Selection of pieces of ordnance. Proportion between their number and that of the combatants. Composition of some artillery trains employed in our African expeditions. Composition and supply of the mountain battery. Lading of the mules. Composition of pontoon trains. Reserve train, boats, wherries, tackle, carriages, and horses. Personnel of the train. Light train: material, personnel.

Sixtieth Lecture.—(4.) Marches of the artillery. Reception of a battery or of a park. Precautions to be taken before the departure. March at a distance from the enemy. Order of march. Distribution of the personnel; halts. Case of an accident to a carriage; ascents; descents; deep-bedded roads; passage through inhabited places; passage of bridges; of fords. Passage over ice. Night march. Transport of mountain artillery. March of pontoon trains. Transport of the trains by water; navigation by convoys; by isolated boats. Transport of ordnance, powder and projectiles in the boats. Transport of artillery trains by sea.

March in the vicinity of the enemy. Isolated convoys; rule with reference to their command; order of march; general measures of security; precautions to be taken during halts; manner of receiving an attack. Case where resistance becomes impossible; arrangements for the night.

Artillery in the march with other troops. Order of march. Relation of the different corps to each other. Exceptional difficulties which may occur on marches; privations of all kinds; bad weather; bad state of the roads; instances. March among high mountains; passes strongly occupied by the enemy; examples.

Encampments and bivouacs. Choice of ground convenient for a camp; disposition of the artillery camp. Establishment of artillery bivouacs. Disposition of the park; precautions relating to the superintendence. Different measures to be taken on arriving on the place of encampment or of bivouac. Attention to be paid to the horses: special precautions for the mules of the mountain artillery. Precautionary measures variable according to circumstances.

Sixty-first Lecture.—(5.) Artillery on the field of battle. Measures to be taken on arriving in the neighborhood of the enemy.

Choice of positions adapted for artillery.

1. Different considerations relative to the ground to be occupied; form of the ground; cultivated lands; nature of the ground; communications, &c.
2. Position of the artillery relatively to the enemy.
3. Position of the artillery relatively to the troops to be supported.

Execution of the fire. Choice of the different kinds of fire according to the nature of the object aimed at and the distance. Fire of cannon, with ball, with shot. Fire of field and mountain howitzers. Fire parallel to the ground. Use of war rockets. General principles relating to the effects to be produced by artillery, and to the warmth of the fire. Proper use of stores; their replacement. Use of the prolong. Arrangements to be made after the engagement. Spiking and unspiking of ordnance.

Use of artillery in the principal circumstances of a campaign. General case of an offensive engagement. Part played by the artillery in supporting infantry and cavalry marching to the attack. Importance of the artillery for following up a first advantage which has been obtained. Examples. Use of the artillery in masses to strike a decisive blow. Examples. Defensive engagement.

Disposition and use of the artillery for the defense of fortified positions. Attack of entrenchments. Reconnaissance. Disposition and use of artillery; attack of lunettes by the gorge. Examples. Attack and defense of villages; disposition of the artillery under these two circumstances. Attack of squares. Importance of artillery towards preparing for it. Examples. Defense of squares; disposition of artillery. Examples. Case of a charge of cavalry upon artillery. Use of artillery in the advanced guard, in the rearguard, in a retreat.

Use of artillery in the passage of streams. Examples. Use of artillery to defend or force the passage of valleys or defiles. Examples.

THIRD SECTION.—SERVICE OF ARTILLERY IN THE ATTACK AND DEFENSE OF PLACES, AND IN THE DEFENSE OF COASTS.

Sixty-second Lecture.—(6.) Object to be attained with the use of artillery in the attack of places. Selection of ordnance, cannon, howitzers, mortars. Composition of the siege train. Method to be followed in order to determine it. Examples of trains employed in different sieges. Carriages of the train. Supply of the siege train with projectiles, powder, &c.

Personnel of the siege train; troops and staff. Transport of the siege train. Horses to be employed. Limit in either direction. Employment of watercourses. Examples. Establishment of the train before the place. Encampment of the artillery force. Organization of the parks. Workshops, powder magazines, trench-depôts. Rules relating to the direction of artillery works. Commanding officers of attack.

Sixty-third Lecture.—(7.) Considerations on the different kinds of batteries to be employed in the attack of fortified places. Position of the batteries relatively to the point to be breached. Direct battery within point-blank range; enfilading battery, for a plunging fire, for direct fire within point-blank range, for plunging fire. Mortar batteries. Composition of the different kinds of batteries. Position of the directing lines of an enfilading battery, relative positions of the cannon, the howitzers, or the mortars. Position of the batteries rela-

tively to the parallels and the rest of the trenches. Examination of the circumstances which affect the power of a plunging fire, command of the work over the battery; distance between the height of the traverses. Slope of the crests of the work.

General principles relating to the order of the works of the artillery, commencing from the opening of the trenches.

Times for the construction of the first batteries. Batteries of the first and second parallels. Use of field artillery to defend the flank of the attacks. Replacement of the fire covered by the advance of the works; batteries of the third parallel. Use of vertical fire. Mortars of 15c. Throwing of grenades. Breaching and counter batteries. Considerations relating to their position. Batteries in the covered way.

Case of a breach into an interior work. Composition of the breaching and counter batteries. Calibres to be used. Number of pieces of ordnance.

Ideas upon the operation of arming batteries. Precautions to be taken. Passage out of the parallels or trenches. March in the trenches; examples of some operations of this kind. Supply of the different kinds of batteries. Rule relating to their daily service. Firing of siege batteries. Opening of the fire. Direct fire within point-blank range. Plunging fire. Fire of mortars. Warmth of the fire by day and by night; mean consumption of material. Fire of breaching batteries. Effects to be produced. Height of the horizontal cutting, number of the vertical ones. Execution of the fire; fall of the revetment. Fire upon the counter forts. Fire to render the breach practicable; balls, shells, war-rockets, facts ascertained by experiment.

Consumption of powder and projectiles, length of the operation. Breaching fire in a very oblique direction. Fire upon masked masonry. Breach into an unreveted work. Fire of counter-batteries. Bombardment. Case where it can be employed; manner of executing it.

Occupation of the place; arrangements which must be made by the artillery. Case of raising the siege. Case of its transformation into a blockade.

Sixty-fourth Lecture.—(8.) Service of artillery in the defense of places. Object to be attained with artillery. Selection of ordnance, guns, howitzers, mortars. Use of war-rockets and arms of precise aim. Field artillery. Basis of the supply of fortified places. Projectiles, powder, small-arms, various carriages. *Personnel* of the artillery. Troops. Staff.

Measures to be taken before the siege. Reconnaissances. Arrangement of the material. Organization of the *personnel*, of the duty by local divisions, of the workshops of all sorts. Precautionary armament. Basis of its organization. Supply of ordnance. Defensive armament. General principles relating to the armament of different kinds of works. Bastions, cavaliers, demilunes, approaches, &c. Organization of the armament. Traverses, embrasures, gun-carriages to be employed. Powder magazines. Supplies. Service of pieces.

Employment of the artillery against the first works of the besiegers, against the construction and armament of batteries; against the besieging artillery. Partial disarmament in case of inferiority. Part played by artillery in sorties. Modification of the defensive armament in proportion to the progress of the attack. Last defensive armament. Principles relating to its disposition. Armament of the flanking part of the fortification. Increased use of vertical fire. Use of war-rockets against works in close proximity. Crowning batteries,

cavaliers of the trenches. Heads of saps, &c. Blinded batteries. Conditions of the establishment. Defense of breaches.

Service of artillery in the defense of coasts. General considerations on the degree of extension admissible in the armament of coasts. Principal points to be defended. Selection of ordnance intended for the armament of coast. Objects to be effected. Effects of balls (utility of large calibres;) of howitzer shells and of shells. Fire with red-hot balls. Material appropriated to the defense of coasts.

Position of coast batteries, conditions which determine it. Composition of coast batteries; their supply. Ideas upon the organization of the batteries and their small redoubts (*réduits.*) Use of the fleet and of field artillery. *Personnel* allotted to the service of artillery on the coasts.

FOURTH SECTION.—APPLICATION OF THE PRINCIPLES PREVIOUSLY SET FORTH TO THE ATTACK AND DEFENSE OF THE FORTRESS OF METZ, (SHAM SIEGE.)

Sixty-fifth Lecture.—(9.) Composition of the siege train necessary for the attack of Metz. Carriages of the train.

Supply of the train with projectiles, powder, &c. Personnel of the train, troops and staff. Transport of the siege train. Establishment of the train before the place; encampment of the artillery force. Organization of the parks. Work-shops, powder magazines and depôts.

Sixty-sixth Lecture.—(10.) Object, disposition, and armament of all the batteries from the first opening of the trenches to the capture of the place. Use of field artillery to flank the batteries, &c.

Service of artillery in the defense of the place. Supply of ordnance, projectiles, powder, small-arms, and different carriages.

Personnel of the artillery. Troops, staff. Organization of the personnel and of the duties by local divisions. Precautionary armament; supply of ordnance. Defensive armament. Armament of the different works. Service of the pieces. Last defensive armament.

Lectures Preparatory to the Labors of the Course.

1. Drawing and tracing of ordnance,	3	lessons.
2. Design for ordnance,	4	"
3. Application of the theories of the course,	1	"
4. Drawing of artillery material,	1	"
5. Tracing of batteries,	1	"

The sixth lecture of the fourth part of the course (the fifty-sixth) is partly devoted to the communication of the instructions necessary for the execution of the work of tracing plans of batteries.

Studies in connection with the Artillery Course.

The practical studies which are connected with the artillery course, are,—

1. Drawing of ordnance,	12	days.
2. The designs for ordnance,	24	"
3. The application of the theories of the artillery course,	6	"
4. The drawings of artillery material,	26	"
5. The tracing of batteries,	4	"
Total,	72	days.

The tracing of batteries is executed by the students of both arms, the other tasks by the artillery students alone.

I. DRAWING ORDNANCE (12 DAYS.)

The survey of ordnance consists in constructing accurate sketches of a gun, howitzer, and mortar, in measuring their dimensions, and in giving a description of each of the pieces drawn. It is on this occasion that the students are practiced in the management of instruments to insure precision, such as the *étoile mobile*, and the sliding compass, &c. One day is devoted to this work.

The tracing of ordnance consists in the execution of a drawing upon colombier paper, containing an exact and detailed representation of a gun, a howitzer, and a mortar, with their projectiles.

This work is performed with the help of the tables for the construction of ordnance. Eleven days are devoted to it.

Detailed Programme of the Drawing.

1. For each gun, howitzer, or mortar, a longitudinal section in the direction of the axis, and at right angles to the axis of the trunnions, and a plan parallel to the axis of the bore and of the trunnions.

Besides this, for those cannon and howitzers which have dolphins, a transverse section taken across the middle of the dolphins and the axis of the trunnions. For mortars, a transverse section made by a plane passing in front of the dolphins, the whole on a scale of one-fifth.

2. Detail of the button (comprising the cascable and breeching loop for naval ordnance) on a scale of two-fifths.

3. Detail of the tracing of a dolphin, on the scale of two-fifths.

4. Tracing of the bush of a gun, on a scale of two-fifths, and tracing of a priming-pan at the real size.

5. For garrison ordnance, in cast-iron, detail of the widening of the base ring on a scale of two-fifths.

6. Tracing of a cannon-ball, of a howitzer-shell, and of a shell, on a scale of one-fifth.

Tracing of the lugs of a shell, ring and lug at the real size.

All the parts of the drawing must be colored in uniform tints in conformity to the table of conventional colors; the annexation of the figures of measurement is not required.

This work is preceded by three or four lectures intended to make the students familiar with the tracings which they have to execute, and the solution of the problems in geometry and descriptive geometry, to which the representation on paper of pieces of ordnance and their projectiles give rise.

II. DESIGN FOR ORDNANCE (24 DAYS.)

The design for ordnance has for its object the complete determination of the nature of a projectile, and of a piece of ordnance in accordance with certain special conditions, inquiring into the laws of the motion of the projectile, and into its principal destructive effects, and the settlement of practice-tables for the

gun. The general case for treatment is that of a howitzer, which comprehends the gun and the mortar as particular cases.

The data usually adopted are,—

1. For the projectile, its weight and the quantity of powder which it is capable of containing.
2. For the piece, the initial velocity of its projectile. This operation comprises calculations, a drawing, and a memoir.

The drawing, on colombier paper, which must be figured in all its parts, contains,—

1. The tracing of the profile of the piece, as it is determined by calculation, so as to satisfy the different conditions of resistance, on a scale of one-fifth.
2. The complete tracing of the piece executed in conformity with the rules laid down for the tracing of ordnance on a scale of one-fifth.
3. Tracing of the projectile on a scale of one-fifth.
4. Tracing of the wooden bottom and of the fuse of the projectile, executed in the case of each of these objects in two figures—the one on a large scale (two-thirds, or even the size of nature,) representing the inquiry into their forms and dimensions, the other giving on a scale of one-fifth the results of this inquiry. To this is added, for the mountain howitzer, or any other howitzer for which it is admissible, a tracing of the mounted howitzer carriage.
5. The representation in drawing of the laws of the motion of the projectile, the trajectory, inclinations, remaining velocities, durations of the passage.

In addition, the scale of the elevations and that of the angles of fire, for an object of aim placed at different distances.

6. An inscription showing all the essential elements by which the projectile and the piece are distinguished.

The final tracings of the gun, the projectile, the bottom, and the fuse, must be colored in uniform tints conformably to the table of conventional colors.

As to the tracing of the profile founded upon the calculation, it should receive merely an edging of the color which represents the metal used.

PROGRAMME OF THE MEMORANDUM ON THE DESIGN FOR ORDNANCE.

INTRODUCTION.

Object of the work. Data of the Question.

A. PROJECTILE.

First Section.—Substance, Forms, and Dimensions.

1. Choice of the metal employed in the manufacture of this projectile.
2. Forms of the projectile.
3. Internal diameter.
4. External diameter.
5. Dimensions of the vent.
6. Diameters of the high and low gauges.

7. Densities of the projectile empty and filled with powder.
8. Weight of the cast-iron ball of the same calibre as the howitzer shell.

Second Section.—Minimum Bursting Charge.

9. Theoretical bursting charge for the hollow sphere.
10. Effect of the shock of the gases, and of their loss through the vent.
11. Résumé of the results arrived at in this chapter.

B. ORDNANCE.

First Section.—Metal, Calibre, and Length of Bore.

12. Choice of the metal of which the piece is to be formed.
13. Windage of the projectile and diameter of the bore.
14. Effect of the windage on the velocity of the projectile.
15. Length of the bore and charge of powder which satisfy the data of the programme.
16. Résumé of the results arrived at in this section.

Second Section.—Thickness of Metal necessary in order that the Piece may resist the Expansion of the Gases.

17. Explanation of the method employed to resolve the question of the thicknesses of metal.
18. First propulsion of the projectile, mean density of the gases after this propulsion.
19. Second propulsion of the projectile, mean density of the gases after this propulsion.
20. Third, fourth, &c., propulsions of the projectile, mean density of the gases after each of them.
21. Density and position of the strata (of gas) at the moment of the maximum of mean density.
22. Density of the last stratum for the positions which come after that of the maximum of mean density.
23. Tensions which result from the densities found.
24. Corresponding thicknesses of metal.
25. Résumé of the results obtained.

Third Section.—Profile of the Piece.

26. Inclosing curve, resulting from the calculations of the second section.
27. Modification rendered necessary by the form of the posterior part of the projectile.
28. Utility of the chamber and its dimensions.
29. Tracing of the chamber and of its junction with the bore.
30. Thickness of metal around the chamber.
31. Chase and reinforce.
32. Determination of the angle of sight.
33. Vent and base ring.
34. Minimum weight of the piece for the resistance of the carriage.

35. Approximate calculation of the weight given by the profile previously obtained. Modification of this profile, if there is any.

Fourth Section.—Trunnions, Breech, and Handles.

36. Dimensions of the trunnions and of the shoulders.

37. Tracing of the breech.

38. Base rings and other moldings.

39. Object and fixing of the preponderance of the breech.

40. Exact settlement of the position of the trunnions, definitive length of the reinforce.

41. Center of gravity of the piece; dimensions and position of the handles.

42. Means of executing the calculations indicated in the two preceding articles.

43. Table of the dimensions of the piece.

C. FIRE OF THE HOWITZER. EFFECTS OF THE PROJECTILE.

First Section.—Elements of the Charging of a Howitzer.

44. Tracing of the shot bottom.

45. Tracing of the fuse.

46. Diameter of the cartridge (or of the bag.)

47. Charge of powder for firing with ball.

Second Section.—Laws of the Motion of the Projectile. Establishment of Practice Tables.

48. Preliminary calculations.

49. Trajectory.

50. Curve of the inclinations.

51. Curve of the remaining velocities.

52. Curve of the durations of the passage.

53. Determination of the elevations for the fire at different distances.

54. Angle of fire, corresponding to the different distances of the object aimed at.

55. Angles of descent.

56. Résumé of the laws of the motion and of the practice tables.

Third Section.—Effects of the Projectile.

57. Depth of penetration in the media indicated by the programme.

58. Effects of explosion in earth.

59. Résumé of the results relating to the effects of the projectile.

NOTE.—The formulas cited in the memoir need not be accompanied by their demonstration, except in the case of the latter not having been already developed in the lessons of the artillery course. It will be sufficient to insert in this notice only the final result of the calculation relating to each formula, without entering into the details of such calculations.

The study of the design for ordnance is preceded by four lessons intended to make the students acquainted with all the details of its execution, and the substance of which is indicated in the programme of the memoir

III. APPLICATION OF THE THEORIES OF THE ARTILLERY COURSE (6 DAYS.)

This study is intended to apply to the students those theories of the course which have not found their application in the design for ordnance. It comprises the solution by arithmetical calculations of certain questions on the effects of powder, the balistic pendulum, the effects of recoil, the science of projectiles, the draught of carriages, &c. The number of the questions may vary according to their nature and the time which their solution requires. The stating of the questions and the results of the calculations are inscribed on separate papers. This study is preceded by a lesson in which the students have recalled to them the formulas which they have to employ.

IV. DRAWING OF ARTILLERY MATERIAL (26 DAYS.)

The drawing of artillery material has for its object the representation by figured sketches of a gun-carriage, carriage, or other furniture of artillery material. The sketches, on paper put together in the form of a book, and headed by a special programme for the object to be drawn, consist of plans, sections, or elevations of the object, executed on certain scales, and of detailed projections of the principal iron-work and joints. The whole fixed by the special programme in question.

All the simultaneous projections of any one part of the object drawn (fore part or hind part for carriages) must be completely figured; they are accompanied by explanatory inscriptions, with letters of reference to show the names of the pieces in wood or metal which they comprise.

Each collection of sketches must contain as well a notice in confirmation of the drawing, giving the complete description and the properties of the object to which it refers.

The students make two surveys of the same kind; eight days are allowed for each of these surveys, including the composition of the confirmatory notice.

The first survey is followed by the execution of an unfigured drawing, containing a complete representation of the object surveyed (elevation and plan,) obtained by the combination of the partial projections contained in the sketch. The drawing should be colored in the conventional uniform tints, and accompanied by an explanatory inscription, with letters of reference. Ten days are devoted to this work of composition.

V. TRACING OF BATTERIES (4 DAYS.)

This work consists in executing sketches showing, each in accordance with a separate programme, the complete plan of a battery and the essential data having reference to its construction and to its armament. The sketches, made by scale and completely figured, must comprise in the case of each battery to be represented—

1. The general plan of the battery, on the scale of $\frac{1}{250}$.
2. The sections or elevations necessary for the understanding of this plan, including the detail of the powder magazines, lines of communication, &c., on the scale of $\frac{1}{100}$.
3. An inscription giving the object of the battery, its armament, its general arrangement (*terre-plein*, embrasures, revetment, communications,

magazines, &c.,) the workmen, materials, and tools necessary for its construction, and finally the duration of the labor and its distribution by day and night.

Four days are devoted to this work, which must be executed on a half sheet of colombier paper. The separate programmes relating to each of these batteries are shown on the study orders of the rooms.

RECAPITULATIVE TABLE.—ARTILLERY STUDENTS.

Lectures.	Number of the Lectures.	Credits given for the Lectures.		Total Credits.	Number of the Questions.	Observations.
		With application at 1h 50m.	Without application at 3h.			
Division of the Course—						
First Part. Theory, Sections 1, 2, 3,	26	18	42	60	4	
Second Part. Description of the Material, Sections 1, 2, 3, 4, 5, 6,	20	20	....	20	3	
Third Part. Fire of Ordnance,	4	....	12	12	1	
Fourth Part. Construction of Batteries,	6	9	....	9	2	
Fifth Part. Organization and Service of the Artillery, Sections 1, 2, 3,	8	....	24	24	1	
Sham Siege,	2	3	....	3	....	
Lectures in preparation for the Studies,	9	13 50	....	13 50	....	
Totals,	75	73 50	78	151 50	10	

Studies.	Number of						Credits in round Numbers.	Observations.
	Sketches.	Drawings.	Memoirs.	Inventories.	In-door attendance, 1½ hours.	Out-door attendance, 1½ hours.		
Survey of Ordnance,	1	....	....	....	....	1	5	
Tracing of Ordnance,	....	1	....	....	11	....	30	
Design for Ordnance—								
Calculations,	....	....	....	1	10	....	45	
Drawing,	....	1	....	....	8	....	35	
Memoir,	....	....	1	....	6	....	55*	* The time is doubled for the Memoirs.
Application of Theories—								
(Artillery Question,)	....	....	1	....	6	....	55†	† Ditto.
First Survey of Material—								
Sketch,	1	....	....	....	....	8	35	
Composition of Notice,	....	1	....	....	10	....	45	
Second Survey—								
Sketch,	1	....	....	....	....	8	35	
Sketch of Batteries,	1	....	....	....	4	....	20	
Totals,	4	3	2	1	55	17	....	

RECAPITULATION.

Lectures, 150
Studies, 380 } 530.

RECAPITULATIVE TABLE.—ENGINEER STUDENTS.

Lectures.	Number of the Lectures.	Credits for the Lectures.		Total Credits.	Number of the Questions.	Observations.
		With application at 1h 30m.	Without application at 3h.			
Division of the Course—						
First Part. Theories, Sections 1, 2, 3,	24	....	72	72	4	
Second Part. Description of the Material, Sections 1, 2, 3, 4, 5, 6,	14	....	42	42	2	
Third Part. Fire of Ordnance,	4	....	12	12	1	
Fourth Part. Construction of Batteries,	6	9	....	9	1	
Fifth Part. Organization and Service of the Artillery, Sections 1, 2, 3,	8	....	24	24	1	
Mock Siege,	2	3	....	3	....	
Totals,	58	12	150	162	9	

Studies.	Number of		Credit.	Observations.
	Sketches.	In-door Attendance.		
Sketches of Batteries,	1	4	20	

RECAPITULATION.

Lectures, 162
Studies, 20 } 182. Round number, 180.

IV. PROGRAMME OF THE COURSE OF MILITARY ART AND FIELD FORTIFICATION.

The course is divided into six parts, and is made up of lectures and works of Application in the Halls of Study and on the ground.

I. LECTURES.

The 1st part contains sundry historical notices on the Organization of Armies,		6	Lectures.
2d part is on Tactics,		3	"
3d "	Castrametation,	2	"
4th "	Field Fortification,	16	"
5th "	Military Communication,	10	"
6th "	Strategy,	6	"
	Total,	43	

FIRST PART.—HISTORICAL NOTICES ON THE ORGANIZATION OF ARMIES.

The first lecture commences with explanations relating to the Greek and Roman armies; their order of battle, mode of marching; comparison of the

Roman Legion with the Greek Phalanx, and of the Roman Legion under Marius and under the Emperors.

2. Military organization of the Franks under the Kings of the first race. Consequences of the feudal system, acting on the military organization. Feudal armies. Chivalry. Crusades, and war against England. Establishment of the first standing armies. Results dependent on the introduction of fire-arms. Progress made in the Art of War and in the organization of armies, from the sixteenth century to the present time.

3. Necessity for standing armies. Their proper character. Recruiting. Promotion. Degrees of rank. Station of the officers. Various positions of military men. On the composition of armies, Infantry, Cavalry, Artillery, Engineers. *Corps d'Etat-Major.* Composition of the army during the Revolution and during the Empire. Actual formation of a French army.

General Staff. Commissariat. (*Intendance.*)—Different services dependent on it.

Relations between the strength of each of the arms that make up an army. On other corps which are not classed among the principal arms.

4, 5, 6. Summary relating to the military organization of the principal Powers of Europe.

SECOND PART—ON TACTICS.

1. Definitions. Formations. Manœuvers; character of a good manœuver. Order of battle: first, of the Infantry; second, of Cavalry; third, of the Artillery; relating to Sharpshooters (*tirailleurs.*)

2. Brief summary of the principal movements in battalion drill to pass from line to the order in columns and reciprocally. Movements in column. Movements in battle. Dispositions to be made against Cavalry.

3. Of the principal movements in line. Order of battle. Line of battle. Formation of Infantry to advance against the enemy. Action of Cavalry. Principal formations. Charges of Artillery. Use of the Three Arms.

THIRD PART.—CASTRAMETATION.

1. General principles of castrametation. Situation. Construction and disposition of barracks. Camp of a Regiment of Infantry, of Cavalry, and of a Battery of Artillery.

2. Manner of tracing a camp on the ground. Huts; details relating to their construction. Tents. Bivouacs. Screens. Kitchens and camp ovens. Choice of the site of a camp; precautions to be taken for its security. Main guards. Advanced posts. Patrols and sentinels.

FOURTH PART.—FIELD FORTIFICATION.

1. Definition of fortification in general. Object and character of field fortification; its utility demonstrated by historical examples. Napoleon's opinion. Essential principle of field fortification. Discussion on the ordinary profile of earthen entrenchments; on the dimensions to be given to the ditch in level ground.

2. Definitions relating to the trace; general principles. Redoubts.

3. On the elements of lines. Relation that should exist between the crest and the internal size of a closed work. Maximum and minimum of the sides of a square redoubt. Defects inherent to the trace of this kind of redoubt. Circular redoubts. Redoubts *en crémaillères.* Star forts. Lines with bastions.

4. Revetments of various kinds; case in which the slope of the ditch should be reveted; choice to be made of the different kinds of revetments.

5. Exterior dispositions; accessories to the defense; abattis; *trous de loups*; palisades; *chevaux de frise*, &c. Precautions to be adopted with reference to such accessories.

6. Interior dispositions; armament of musketry, artillery, barbettes, and embrasures; their advantages and disadvantages; construction of.

7. Powder magazines of different kinds. Small earthen entrenchments; palisades, carpentry, or blockhouses; advantages and disadvantages of blockhouses. African blockhouse. Closing of field-works.

8. Artificial inundations; under what circumstances they can be considered as obstacles. Positions and dimensions of dikes. Details of their execution; what advantage can be drawn from an inundation having less than five feet depth of water.

9. What is understood by the defilading of a work. The defilading of field-works should, above all things, be made to depend on their trace and situation. Definitions: dangerous ground; dangerous points. Defilement of an isolated and closed work; in what case it is practicable. Use of traverses. A partial defilement may sometimes be sufficient.

10. Continuous lines. Broken lines. Traces of redan, tenailles, cremailleres. Bastioned lines. Comparison between continuous and broken lines. Principal objections to their use. Utility of each demonstrated under certain circumstances.

11. Lines in broken ground: their form should depend on the nature of the ground. On the manner of fortifying a table-land. Expedients for defilading portions of lines. On the manner of making use of the natural obstacles of the ground; forests, scarps, marshes, water-courses, &c. Method of fortifying a house, village, an open town. Defense of a bridge or road.

12. *Têtes de pont.* Utility of small earthen entrenchments in these cases to facilitate the passage of a retreating army. Traces of a large *tête de pont.* Principal circumstances relating to the use of lines in war. Lines of circumvallation and countervallation. Frontier lines. Retrenchments against a descent. Lines that an army should make in an enemy's country, far from its base of operations. Entrenchment on the field of battle. Lines, mixed, proposed by General Rogniat.

13. Attack and defense of entrenchments, of a continuous line; of a line at intervals; of an isolated work, &c. Examples of the attack and defense of lines.

14. Instruction relating to the operations for profiling and defilading on the ground.

15. Instruction on the project of field fortification. Calculation of the dimensions of a ditch corresponding to the face of a work of a variable relief, and to be constructed in level or other ground. Details relating to traverses, small entrenchments; defensive caponnieres, and accessories to defense, &c.

16. On the construction of entrenchments. Practical operations and organization of workshops to obtain durable and solid work. Necessity, in most cases, for accelerating the construction of entrenchments. Vauban's precepts. In what manner the work must proceed to obtain a useful result; and, in the event of plenty of hands, how to finish it promptly.

FIFTH PART.—ON MILITARY COMMUNICATIONS.

1. On roads. 1 and 2, Classification of roads. Section and trace of roads in level and mountain country. Details connected with the study of a project for a road. Particular conditions relating to military roads. Execution of paved and macadamized roads. Roads for passing difficult places by the use of fascines, logs, &c. Maintenance and destruction of roads.

2. On military bridges.

3. Observations on the currents and change of form in the bed of rivers. Fords. Transverse sections, &c. Reconnaissances of rivers. Properties essential to military bridges. Relation between the buoyancy and the load in the case of floating supports. Anchorage. Construction of the abutments. Means of rendering bridges stable.

4. Construction of a bridge of boats in different ways. Bridges made of ordinary boats. Method of withdrawing a bridge of boats.

5. Raft bridge. Relation between the weight and the extrinsic load of a raft. Number of trunks of trees required for a raft bridge on a river of given dimensions. Weight of the trunk of a tree. Number and space between rafts. Construction of a raft and a bridge of rafts. Bridges of casks and trestles.

6. Rope bridges; their use. Calculations respecting the tension and diameters of ropes. Construction of a suspension bridge, and calculations relating to it.

7. Bridges on piles, carriages, gabions, &c.

8. Measures to be taken for the preservation of military bridges. Destruction of military bridges; also of masonry bridges. Reëstablishment of bridges.

9. Flying bridges. Ferry-boats, tubs, passage by fords, on the ice, by swimming.

10. Execution of the passage of rivers. Advancing and in retreating. Examples.

SIXTH PART.—STRATEGY.

1. Definition. Fundamental principles of all operations in war. In all cases there are—first, the base of operations; second, the point to be arrived at; third, the line of operations. Strategetical points and lines.

2. On marching. Preparatory and manœuvering marches. Advanced and rear guard. On provisions. System of magazines. Requisitions. Invasions. Battle. Examples.

3. On positions. War in a mountainous district. Retreats. Pursuit. Convoys. Partizans.

4. Winter quarters. Cantonments. War against irregular bands. Military reconnaissances.

5. Precis of the campaigns of the French armies.

6. Analysis of the principal campaigns of great captains.

II. PROGRAMME OF THE WORKS OF APPLICATION EXECUTED IN THE HALLS OF STUDY.

These works consist of four Plates of Drawings, two Memoirs, and a Project of Field Fortification. Of the four Plates of Drawings, two relate to Field Fortification, and two, accompanied by Memoirs, relate to Military Communications.

Plate 1.—Elements of lines. Tracing, on the scale of $\frac{1}{1000}$ of the interior crest (only) of a redan, lunette, redoubt, star fort, bastioned fort, according to particular data given to each Sous-Lieutenant. Construction on the scale of $\frac{1}{100}$ of a complete profile for each of these works, supposed to be established on level ground. Complete calculation of the deblais and remblais for one of the preceding works, according to the instructions of the Professor.

Plate 2.—Details of a field-work. Trace on the scale of $\frac{1}{100}$ of a portion of the work of which the deblais and remblais has been calculated. Graphic construction of a barbette and of a direct or oblique embrasure. Details of revetments in fascines, hurdles, turf. Pisé. Drawing of a blockhouse.

Plate 3.—Accompanied by a Memoir. Project of a portion of road on ground represented by certain lines, according to certain data.

Plate 4.—Accompanied by a Memoir. Military bridges.

1. Drawing of a portion of a bridge of boats, three openings being shown; the two first relating to the successive construction of the bridge, and the third, of the construction by portions.
2. Project for establishing a raft bridge; the width of the river; the kind of troops to pass over the bridge; the length; mean diameter of the available trunks of trees and the length and scantling of the joints being given. The drawing to exhibit a plan of two openings of the bridge, and a transverse section.
3. Tressel bridge. To draw a longitudinal elevation and a transverse section of a tressel bridge, being given the length of the top and of the feet of the tressels up and down the stream.
4. Project for the repair of a broken arch; being given the opening of the head, the elevation of the roadway of the bridge above the level of the water; the depth of the water, the rapidity of the current, the kind of troops to pass over the bridge, and the available time and the resources as regards men and materials which can be had recourse to.

Programme of the Project of Field Fortification.

This project is made by the Sub-Lieutenants, according to certain data given to each of them. It has for its object to cause them to study:—1st. The trace. 2d. The complete organization necessary for its defense. 3d. The details of construction of a field-work. In consequence, the work comprises three Plates of Drawings and a Memoir divided into three parts.

Programme of the Drawings.

Plate 1.—Plan of the whole. This plate has for its object the research of a trace and of a combination of suitable works for the fortification of a certain portion of ground under certain circumstances of war defined by particular data. Each Sub-Lieutenant receives a lithographed sheet representing the ground to be fortified, and he has to exhibit on this sheet the works he proposes, in tracing in plain lines the horizontal projections of the interior crests and superior limits of the ditch, and in dotted lines the stockades or palisades; to show in black figures at the angles of the works the relief of the interior crests; the sites of barbettes, embrasures, traverses, barriers, &c., being indicated by reference letters and explanatory notes, the lines in red showing the directions and objects of the line of fire.

Plate 2.—Organization of a work.

This plate has for its object the study of the details of the interior and exterior organization of a work of a certain form, in order to render it susceptible of making a good defense.

Each Sub-Lieutenant will draw a complete plan of such one of the works shown on Plate 1, as may be pointed out by the Professor. He will represent the ditches, parapets, embrasures, accessory defenses, small entrenchments, descents into the ditch, &c., according to the particular data furnished to him; the figures of the relief of the crests of all kinds, the deblais and remblais being marked at all the angles. The figures of the natural ground will be underlined. The same plate will contain figured profiles which have served for the determination of the complete projection of the work. Scale $\frac{1}{2\,5\,0}$.

Plate 3.—Details of construction.

The object of this plate is to show the composition of workshops and the manner that should be adopted in the construction of field-works, according to circumstances, for the execution of the deblais and remblais.

Each Sub-Lieutenant will indicate the manner in which the work drawn on Plate 2 should be constructed:—1st. To render it durable and solid. 2d. To arrive rapidly at a useful result, even with limited resources of workmen and tools. 3d. To finish the work in the shortest possible time, by making use of all the necessary means. A plan will show the composition of the workshops under each of these hypotheses, and the successive advancement of the work will be represented by certain profiles supposed to be made at certain periods of the construction through the center of one of the faces of the work. In these profiles a firm trace, figured with altitudes, will show the limits of the deblais and remblais at the period represented by the profiles; and in addition, by dotted lines, the final results proposed to be obtained. All these projects must be accompanied by a figured plan, showing the principal altitudes in meters. The remblais will be colored with gamboge, the undisturbed earth in bistre, and the deblais will be left white.

Programme of the Memoir.

Each Sub-Lieutenant will write at the head of his Memoir the text of the particular programme, to which he is obliged to conform in the preparation of his project, and he should add to the text of the Memoir all the sketches properly figured, which are necessary for the proper appreciation of the dispositions which are not sufficiently detailed on the Drawings.

The Memoir is divided into three parts, corresponding to the three Plates of Drawings.

FIRST PART.—CONSIDERATIONS RESPECTING THE WHOLE PROJECT.

1st. General principles, according to which it would be proper to trace the works indicated in the particular programme, such as lines at intervals, continuous lines, têtes de pont, &c.

2d. Description of the tracing in Plate 1. Reasons deduced from the form of the ground or the nature of the military operations that led to the adoption of the trace. Object of the works, and their connection with each other.

3d. Number, description, and position of the pieces of artillery composing the armament.

4th. Maximum and minimum of troops that could be employed in the defense of these works.

5th. Dispositions which should be adopted (relatively to the necessary preparations in materials and to the separation and movement of troops) for the attack and for the defense.

SECOND PART.—COMPLETE ORGANIZATION OF A WORK.

1st. Particular object of the work shown in Plate 2: Trace of the complete projections of the parapets, barbettes, ramps, embrasures, traverses, &c.

2d. Conditions that should be fulfilled by the ditch. Approximate calculation of dimensions which should be given to it, taking into account the increased means of providing for an excess or defect of the deblais.

3d. Discussion on the site and the part which might be expected from small entrenchments, accessory defenses, shutters, descents of ditches, &c.

4th. Site of powder magazines; capacity that should be given to them, suitable to the state of the munitions necessary for the armament of the work.

THIRD PART.—DETAILS OF CONSTRUCTIONS.

1st. Means of ascertaining the nature of the earth; considerations respecting relays for the transport of earth with the shovel.

2d. Description, number and disposition of the workmen in a shed for deblai and remblai, according to the nature of the ground and number of relays.

3d. Explanation of Plate 3. Organization of the sheds and conduct of the work where the duration and solidity of the work are the greatest essentials; where, on the other hand, rapidity of execution is the principal thing to be fulfilled.

4th. Which of the modes of construction exhibited in Plate 3 it would be desirable to employ for the proposed works, according to the circumstance specified in the particular programme. Calculation for this mode of construction, of the time and of the numbers of men and tools necessary for the execution of the deblais and remblais of the work given in the plate.

5th. Details of construction of the revetments, magazines, shutters, accessory defenses, artillery platforms, &c.

III. PROGRAMME OF EXTERIOR WORKS.

These works consist of an exercise in tracing out a camp, and an exercise on the profiling and deflement of field-works.

The exercise on tracing camps has no particular programme, but is preceded by a lecture given by the Professor.

Programme of Practical Exercises on the Defilement and Profiling of Field Works.

This exercise comprehends: 1st, work on the ground; 2d, a Memoir.

The work on the ground has for its object: 1st, the trace of the projections of the interior crest of a work, whose position and form are known; 2d, the determination of the relief of the interior crest; 3d, the profiling of the different parts, so that the relief of the different parts of the parapet, barbettes, traverses, &c., may all be fixed.

The Sub-Lieutenants for this kind of work are divided into groups of six or eight, employed together on the same work, each group being divided into two squads. The work may be a lunette or a redan of given dimensions, having a

parapet of three meters thick, and a natural slope of one to one. 1st. The direction of the capital will be marked out in front by two numbered pickets. 2d. The tracing will be executed by means of poles or pickets placed at all the angles, and at the extremities of the gorge; the relief will be determined by the practical methods of defilement adverted to in the lecture which preceded the work.

3d. The relief obtained by the defilement will be marked on all the poles or pickets placed at the angles, and at the extremities of the sides of the work.

4th. On each face two vertical profiles will be executed, perpendicular to the horizontal projections of its interior crest. In order that these profiles shall not interfere with those placed at the angles, they must be established at several meters distant from the extremity of each face.

5th. The profiles of the angles will be deducted by simple prolongations, and the same for the profiles of the gorge. If the homologous crests of two contiguous faces do not meet each other, they should be reconciled by joining two points taken on each of them at half a meter from the intersection of their projections.

6th. On the traverse, designed to secure the defenders from a reverse fire, two profiles are constructed, near to its extremities if its crest is a right line, but if it is bent, another profile must be set up at the junction.

7th. The data of all these profiles are, the relief of the interior crest at the point where it is encountered by the profile, the thickness of the parapet, the constant parts of every profile, and the natural slope of the ground; the portion of the slope of the traverses exposed to the view of the dominant heights should not be reveted, the others should be.

8th. At the points of intersection of the profiles with the projections of the ridges of the works, as well as at the points used for adjusting, poles or pickets are placed, on which the points belonging to the ridges are marked. These points will be joined together in each profile by twine, indicating the different planes of the work.

9th. The form and dimensions of the batteries, either of barbettes or embrasures, will be equally determined by poles or pickets placed at all their angles, and united together by twine in the manner that will be subsequently explained.

10th. For the barbette batteries, the first thing to be done is to establish and to construct the front coupé of the salient of the interior crest, and substitute an interior horizontal crest throughout the extent of the barbette for that situated in the plane of defilement. The necessary adjustments are then made between the slope of the parapet of the barbette and that of the rest of the face, and indicate by means of twine the intersections of the terre-plein of the barbette and of its slope with the different planes of the work.

11th. For the embrasures, after having determined their direction, the intersections of the cheeks and bottom, with the interior and exterior slope of the parapet, and with its slope; also the slope which terminates the interruption of the banquette throughout the extent of the battery. In the case where the platform is formed more than $0^m.4$ elevated above the soil, a ramp is constructed with its slope, and the intersections with the slope from the platform are shown.

12th. After the batteries, the slope of the ends of the traverses and of the passages for entry and exit are constructed.

13th. The traverse will be finished by adjusting its different planes with

those of the parapet. In the particular case, where it was interfered with to make a passage over the banquette, it is finished by reveting the slope passing by the crest of the banquette of the work.

14th. At the passages of entry and exit from the work, the parapets will be finished by the slope of the revetment, whose intersections with the different planes of the parapets must be determined.

15th. For each squad of workmen, the distance of the salient of the work to the point on which it will be defiladed must be determined.

MEMOIR.

1st. Object of deflement—which is considered to be dangerous ground, dangerous point, plane of deflement.

2d. Position of the dangerous point relatively to the work which is to be defiladed. Practical method on the ground. Results to which it leads.

3d. On the field this method is not always applicable to an isolated work, and never is so to entrenchments of a great development, such as lines, large têtes-de-pont, &c. By what proceeding is it generally expedient to attempt to fulfill in war the indisputable condition of deflement.

RECAPITULATION FOR THE SUB-LIEUTENANTS OF ARTILLERY AND ENGINEERS.

First Lectures.—Parts of the Course.	No. of Lectures.	Credits for Lectures.			No. of Interrogations.	Observations.
		With application.	Without application.	Total.		
1st Part. Historical notions on the Organization of Armies,	6	.....	18	18	1	The number 20 is applied to the interrogations and to the obligations of the week.
2nd Part. Tactics,	3	.....	9	9		
3rd " Castrametation,	2	.....	6	6		
4th " Field Fortification,	16	24	.....	24	2	
5th " Military Communications,	10	15	.....	15	1	
6th " Strategy,	6	.....	18	18	1	
Totals,	43	39	51	90	5	

Execution of Work.	Number of Drawings.	Number of Memoirs.	Attendances. In the Halls.	Attendances. Outside.	Credits.	Observations.
Drawings of Military Art,—						
Plate 1. Elements of Lines,	1	.....	4	.....	20	
" 2. Details of a Field-work,	1	.....	8	.....	25	
" 3. Project of a Road,	1	.....	8	.....	25	
Memoir,	....	1	1	.....	10	
Plate 4. Military Bridges,	1	.....	8	.....	25	
Memoir,	....	1	2	.....	20	
Project of Field Fortification,—						
Plate 1. Plan of the whole,	1	.....	3	.....	15	
" 2. Organization of a work,	1	.....	8	.....	25	
" 3. Details of Construction,	1	.....	5	.....	20	
Memoir,	....	1	3	.....	20	
Tracing of Camps,	....	.....	.....	1	5	
Tracing on the ground,	....	.....	.....	2	10	
Memoir,	....	1	1	.....	10	
Totals,	7	4	51	3	260	

RECAPITULATION OF THE CREDITS OF INFLUENCE.

Lectures,	90
Execution of Work,	260
Totals,	370

4th. Methods of defilement employed. Determination of the different planes of barbettes, of their ramps, of the profiles of the gorge, &c. Construction of embrasures.

5th. Means made use of in practice for determining the distance of the salient of the work to the dangerous point on which it is defiladed.

V.—PROGRAMME OF PERMANENT FORTIFICATION, AND THE ATTACK AND DEFENSE OF PLACES.

The course of instruction in Permanent Fortification and the Attack and Defense of Places, is divided into three parts, viz:—

	No. of Lectures to	
	Artillery.	Engineers.
The first part consists of the study of the Construction of existing Fortifications, and it is common to the two services; it comprises,.....	10	10
The second part contains the principles of the Art of Fortification, divided into three sections, of which the.... 1st section relates to Fortification on level ground,.....	19	19
2nd section relates to Fortification on hilly ground,.....	19	26
3rd section relates to general questions of Fortifications, ...	4	5
Third part relates to the Attack and Defense of Places,.....	24	24
Total number of Lectures,.....	76	84

The first part contains a description of the various works of permanent fortification, their respective uses, and the changes that have been successively made in them, together with a short history of ancient fortification prior to the invention of powder, and the changes introduced by the use of fire-arms.

The systems of Errard, Beville, Pagan, Vauban, Coehorn, and Cormontaigne.

The first section of the second part describes the principles on which the various parts of a front of fortification on level ground, and according to Cormontaigne's system, are regulated, such as the command, relief, defilement, form, length, and material of which the various parts should be constructed; the modifications required by the absence or presence of water; the changes which are necessary as regards exterior or advanced works, and ending with a comparison of a front of fortification according to Cormontaigne, with a modification of the same system introduced by the French engineers.

The second section commences with the principles of defilement and its application under various given circumstances, proceeds with the description of an imaginary work founded on certain given data, and furnishes the data of its proposed construction. It then supplies the theory relating to mines, and their use in the attack, defense, and destruction of places, and points out the particular duties of engineers in fortified places, and the proper and most efficient manner of carrying them on.

The third section relates to the preparation of projects for the improvement of inefficiently fortified places, and to the utility, particular organization, and proper position of fortified places on a frontier line. It then explains the necessity for military law in providing for the security of fortified places and districts along the frontiers of a state.

The third part describes the various operations connected with the attack and defense of a bastioned fortification, commencing with the operations preliminary to the siege and investment of the place, and continuing to describe the

several processes to be employed in the attack of the place, with the corresponding efforts that should be made during its defense, and ending with an historical account of certain sieges.

This course requires the practical completion of the following:

Nature of the Work.	Time allowed for its completion.	Subject of the Work.	Scale.	
		1st Part.—On existing Fortifications.		Observ'ns.
Single Plate,	20 days,	Complete projection of the front of Cormontaigne without counterguard or cavalier,	1/1000	Common to Students of both Services.
		Three profiles of the front,	1/500	
		2d Part.—Principles of the Art of Fortification.		
Plate, No. 1,	8 "	1st Section: Fortifications on level ground.—Principal graphical constructions of the front on level ground according to particular data given to each Student.	1/1000	
Plate, No. 2,	28 "	Complete projection of the whole of the visible and underground parts of the same front,	1/1000	
		Three profiles of the front,	1/500	
Memoir, ...	6 "	Description of the principles of the Fortification, with a detailed discussion of the dispositions adopted in the particular case treated by the Students.		
Plate 3, ...	20 "	2d Section: Fortification on hilly ground.—Drawing of the ideal fortress and of its Tête-du-pont, with the interior entrenchments, inundation, sluices, and all necessary details to enable a proper comprehension to be had of the action of the water.		
		Drawing complete of one of the fronts of the place and its outworks, described by a particular programme. Defilement of all the works of this front and of the masonry of one of its faces,	1/500	
Memoir, ...	3 "	On the situation of the fortification; description of the imaginary fortress, and of the management of the water; explanation of the operations of defilement drawn on Plate 3.		
Plate 4, (Artillerie.)	10 "	Plan and profile of a full revetment of the escarp with its counterforts,	1/100	Artillery.
		Plan, profiles, and elevation of a revetment "en décharge."	1/100	
		Detail of a gallery and small chamber of a mine, of its tamping and mode of firing.	1/50	
Plate 4, (Engineers.)	20 "	Detailed project of one of the parts of the front of fortification defiladed in Plate 3. Plans at different height; disposition of the galleries and small chambers of mines required for blowing up the whole of the ground between two listening galleries,	1/100	
Plate 5, ...	10 "	Sections and elevations of the preceding project. Foundations, coping of vaults, dressing of cut stones, &c.,	1/100	
		Detail of a small gallery and chamber of a mine, comprised in the dispositions of Plate 4. Tamping and mode of firing.	1/25	
Avant, ...	3 "	Abstractions of measurement of a part of the preceding project,	.....	Special to Engineer Students.
Plate 6,.....	11 "	Study of the alterations in the earth of the same part of the projects, representing the four principal periods of the work, by a plan and section, with an elevation of the 4th period,	1/100	
Memoir, ...	2 "	General theory of the removal of earth. Application to a particular project,	.....	
Register,....	2 "	Register of the removal of earth as represented in Plate 6.		
Estimate, ...	1 "	Estimate of the part of the project to which the abstraction of measurements has been applied.		
		3d Section: Projection of the improvement of an existing fortified place.		
Plate 7,.....	30 "	Complete projection of the project for improving an existing fortified place,	1/1000	
Plate 8,.....	6 "	Details of the most interesting parts of the project, in plans, sections, and elevations,	1/100	
Memoir, ...	2 "	Marginal notes on the defects presented by the existing system, and on the means employed for correcting them.		
Calculation,	5 "	Balance of the "deblais" and "remblais" of the project.		
		3d Part.—Attack and Defense of Places.		Common.
Single Plate,	30 "	Project of attack of a front of fortification on level ground,	1/1000	
		Details of the attack.	1/100	
Journal, ...	4 "	Journal of the siege. Details relating to the composition of the garrison and of the besieging army; also on the material for the Artillery and Engineers required for the attack and defense. Pen sketch of the most elementary works of attack.		

RECAPITULATION FOR THE ARTILLERY.

I. Lectures. Parts of the Course.	Number of Lectures.	Credits for the Lectures.			Number of Interrogations.	Observations.
		With application (a.)	Without application (b.)	Total.		
First Part. Study of existing Fortifications,.....	10	4.5	21	26	1	(a.) The Lectures with application count for 1 hour 5 minutes. (b.) These without application for 3 hours.
Second Part. Principles of the Art of Fortification,..	....	....	....	.....	....	
First Section. Fortification on level ground,....	19	24.0	9	33	2	
Second Section. Fortification on hilly ground,....	19	19.5	18	38	2	
Third Section. General questions of Fortification	4	....	12	12	....	
Third Part. Attack and Defense of Places, ...	24	24	24	48	2	
Totals,.....	76	72	84	157	7	

II. Execution of Work.		Number of				Credits.	Observations.
		Drawings.	Memoirs.	Various.	Sittings in the Halls of Study.		
First Part.	Front of Cormontaigne,.....	1	..	..	20	20	
Second Part.	Plate 1. Construction of Project on Level Ground,.....	1	..	..	6	12	
	Plate 2. Project on Level Ground,.....	1	..	..	28	125	
	Memoir on ditto,.....	..	1	..	6	55	
	Plate 3. Project on Hilly Ground,.....	1	..	..	20	20	
	Memoir on ditto,.....	..	1	..	3	20	
	Plate 4. Project of Details. Plan,.....	1	..	..	20	20	
	Plate 5. Project of Section. Plan,.....	1	..	..	10	45	
	Abstraction of Measurements,.....	..	..	1	3	12	
	Plate 6. Removal of Earth,.....	1	..	..	11	50	
	Memoir on ditto,.....	..	1	..	2	20	
	Register of ditto,.....	..	..	1	3	12	
	Estimate of the Project,.....	..	..	1	1	10	
	Plate 7. Project of Improvements,.....	1	..	..	20	125	
	Plate 8. Details of ditto,.....	1	..	..	6	25	
	Memoir on ditto,.....	..	1	..	2	20	
	Balance of Deblais and Remblais,.....	..	..	1	5	45	
Third Part.	Project of Attack,.....	1	..	..	20	125	
	Journal of the Siege,.....	..	1	..	4	35	
	Totals,.....	10	5	4	212	1,085	

RECAPITULATION OF THE CREDITS OF INFLUENCE.

Lectures,.....	165	1,250
Execution of Works,.....	1,085	

RECAPITULATION FOR ARTILLERY—*continued.*

II. Studies and Execution of Work.		Number of Drawings.	Number of Memoirs.	Number of Sittings in the Halls of Study.	Credits.	Observations.
First Part.	Front of Cormontaigne,.....	1	..	20	20	
Second Part.	Plate 1. Construction of the Project on Level Ground,.....	1	..	8	25	
	Plate 2. Project on Level Ground,.....	1	..	28	125	
	Memoir,.....	..	1	6	55	
	Plate 3. Project on Hilly Ground,.....	1	..	20	90	
	Plate 4. Details of the Project,.....	1	..	10	45	
	Memoir,.....	..	1	3	30	
Third Part.	Plate. Project of Attack,.....	1	..	30	135	
	Journal of Attack,.....	..	1	4	35	
	Totals,.....	6	3	129	640	

RECAPITULATION OF THE CREDITS OF INFLUENCE.

Lectures,.....	160	800.
Studies and Execution of Work,.....	640	

RECAPITULATION FOR THE ENGINEERS.

I. Lectures.		Number of Lectures.	Credits for Lectures: With Application.	Credits for Lectures: Without Application.	Credits for Lectures: Total.	Number of Interrogations.	Observations.
First Part.	Study of existing Fortification,.....	10	4.5	21	26	1	The number 162 is applicable to the Interrogations.
Second Part.	Principles of the Art of Fortification,...	..	..	..	..	..	
	First Section. Fortification on Level Ground,.....	19	24.0	9	33	2	
	Second Section. Fortification on Hilly Ground,.....	26	36.0	6	42	2	
	Third Section. General Questions on Fortification,.....	5	1.5	12	13	..	
Third Part.	Attack and Defense of Places,.....	24	24.0	24	48	2	
	Totals,.....	84	90.0	72	162	7	

VI. PROGRAMME OF THE COURSE OF TOPOGRAPHY.

The course of Topography comprehends two parts.

The first relates to the art of topographical drawing, and the second to the art of making topographical surveys. Both parts are carried on *pari passu;* but as the order in which the different branches of the instruction can be given depends very much on the other works carried on in the School, it will be more convenient to give the programme for each separately.

FIRST PART.—INSTRUCTION IN TOPOGRAPHICAL DRAWING.

The instruction in topographical drawing comprehends lectures and exercises in graphical representation. It is based on a complete exposition of the conventional principles of this species of drawing, and it is illustrated by engraved examples of the characteristics adopted for the representation of the various details.

First Section.—Lectures.

The lectures have for their object the explanation of the general principles of the instruction in topographical drawing, and the geometrical conditions which should regulate the shading of maps and their reduction. They immediately precede the exercise to which they relate.

Lecture 1 relates to small maps, copies, and reductions of these; and it explains the object of topographical maps, the various kinds and the different scales generally used. The manner in which the form of the ground is represented by equi-distant contour or level lines is also explained, and mention is made of the conventional tints used, and the species of writing and value of the scale employed.

Lectures 2 and 3 relate to the execution of shaded plans by the brush and the pen, under different circumstances of light and shade.

Lecture 4 explains the different methods for reducing topographical maps, also the description, mode of using, and verification of pentagraphs.

Second Section.—Exercises.

These exercises are intended to teach the students the conventional signs used in topographical drawing, and to give them facilities with the pencil and brush for producing shaded maps, and in reducing them from one scale to another.

SECOND PART.—INSTRUCTION IN TOPOGRAPHICAL SURVEYING.

This instruction comprises:

1st. Lectures given in amphitheatre.
2d. Practical lectures or exercises.
3d. The execution of topographical surveys.

First Section.—Oral Lectures.

These lectures are divided in two classes, which comprehend:—

1st. Those relating to the description of the instruments, and of the methods used in topography.

2d. Those which have reference to the manner in which the students should proceed in the execution of the work, and principally of surveys of limited extent.

Eight lectures are devoted to the description of the various instruments, the method of adjusting their errors, and the manner of using them, as well as to the different ways of proceeding in topography; touching also on the various modes of measuring distances, with descriptions of the compass, plane table, and instruments used for leveling, and on the taking observations for and preparation of sections, and the orientation of maps.

Four preparatory lectures are given, showing the manner in which the students should proceed when on the ground to make a survey of small extent.

Two lectures relate to the methods that should be employed in making a survey of considerable extent, and on the appropriate scales.

Two lectures on military reconnaissance plans; instruments and scales employed.

Two preparatory lectures relate to the execution of a reconnaissance plan, in which the operations of a sham siege are intended to be recorded.

Second Section.—Practical Lectures or Exercises.

The object of these lectures, which take place on the glacis of the fortification, is to show the students the practical modes of using the instruments, and the precautions which must be taken, together with the most elementary proceedings in topography. They are given to ten or twelve students at the same time, and the Professor is assisted by an officer of the staff. Each lecture lasts two and a half hours.

Third Section.—On the Execution of Topographical Surveys.

The object is to familiarize the students with the use of the principal instruments and the principal operations, and they comprehend out-of-door work, of which the results are sketches, registers, and minutes made in pencil, and in the construction of plans, and inking in of the minutes in the Halls of Study.

The out-of-door work is performed under the superintendence of officers of the staff, who assist the students in their work. The construction of the plans is not commenced until the pencil minutes have been examined by the Professor.

These exercises comprise:—

1st and 2d. Construction of plans by the aid of the compass.
3d. The plan of a fortification made with the plane table.
4th. The determination of the variation of the compass.
5th. The execution of a second survey by the aid of the compass.
6th. " " rapid survey by pacing the distances.
7th. " " reconnaissance survey.
8th. " " an itinerary and reconnaissance sketch.
9th. The preparation of a plan on which the whole of the operations of a sham siege may be laid down, as the works of attack and defense proceed.

RECAPITULATION FOR THE ARTILLERY AND ENGINEERS.

Lectures.	Number of Lectures.	Credits for Lectures. With Application.	Credits for Lectures. Without Application.	Credits for Lectures. Total.	Number of Interrogations.	Observations.
1st part:						
Topographical Drawing,	4	6	.....			
Art of Surveying—						
On the instruments and Topographical processes,	8	12	.....	36	2	
On Surveys of considerable magnitude,	2	.....	6			
On Reconnaissance Plans,	2	1.5	3			
Preparatory to out-of-door work,	5	7.5	.....			
Total	21	27	9	36*	2	

* The credit is diminished here and carried forward to the exercises, which serve for the interrogations of many lectures. These lectures have therefore really three series of interrogations.

RECAPITULATION—*continued.*

Execution of Work.	Number of Drawings.	Memoirs.	Various.	Attendances In the halls.	Attendances Out of the halls.	Attendances Out of doors.	Credits.	Observations.
1st Part:—								
Topographical Drawing:								
Conventional Tints,	1	....	....	3	....	....	10	
Study of Maps,	4	....	....	26	....	....	120	* The description Itinerary is reckoned with the simulated siege operations.
Reduction,	1	....	....	2	....	....	10	
Construction of a Triangulation with the Compass,	1	....	....	3	....	....	15	
1st Survey with the Compass:								
Out-of-door work,	....	....	1	....	....	6	50	
Laying down,	1	....	....	4	....	....	20	
Survey of Fortifications with the Plane-table:								
Out-of-door work,	1	....	1	....	....	10	80	† For a Memoir.
Laying down,		1	....	4	....	....	25	
Determination of the Variation of the Compass,	1	....	....	1	1h	....	5	
2d Survey with the Compass:								
Out-of-door work,	1	....	1	....	....	8	65	‡ This number is formed with 5 taken from it for the credit of the interrogations because the exercises serve for the interrogations of several lectures.
Laying down,	1	....	....	2	....	....	10	
Rapid Survey:								
Out-of-door work,	1	....	1	....	....	6	50	
Laying down,		1	....	4	....	....	25	
Reconnaissance Survey:								
Out-of-door work,	1	....	1	....	....	4	30	
Laying down,		1	....	3	....	....	20	
Itinerary and Reconnaissance,*	1	....	....	....	....	1	10	
Topographical operations relative to a sham siege†	....	....	....	....	....	....	....	
Topographical exercises, each of 2½ hours duration,	....	....	....	....	6	....	20‡	
Total	15	3	5	52	7	35	565	

RECAPITULATION OF THE CREDITS OF INFLUENCE.

Lectures, ... 30
Execution of work, ... 565
} 595.

VII. PROGRAMME OF THE COURSE OF GEODESY AND DIALLING.

This course is divided into two parts—the one part special for the engineers, and the other common to the artillery and engineers.

The first comprises:—

1st. The study of the execution of a triangulation of some extent, and of its connection with the general triangulation of France, executed under the superintendence of the Dépôt de la Guerre, and

2d. Leveling with the barometer.

The second contains:—

1st. The study of reflecting instruments.

2d. The principles of dialling.

Each of these parts comprehend:—

1st. Lectures given in the amphitheatre.

2d. Practical lectures or exercises.

3d. An application.

FIRST PART.—SPECIAL FOR ENGINEERS.

1st Section—Lectures.

These Lectures include:—

1st. A description of the principal geodesical instruments.

2d. The establishment of the triangulation.

3d. The survey and the calculations connected with it.

4th. The orientation of the triangulation.

5th. The calculation of the co-ordinates of the points and their construction from the minutes of the survey.

6th. The geodesical and barometrical leveling.

The first lecture is devoted to the explanation of the different kind of signals used under various circumstances; on the method of measuring bases and angles, and the principles on which these operations are performed; and concluding with the description and mode of using certain instruments for measuring angles.

The second lecture continues and enlarges on the subject of the measurement of angles, horizontal and vertical, with different kinds of instruments.

The third lecture relates to the corrections and reductions which must be made to observed angles, such as the correction for the eccentricity of the instruments, to the reduction of the angles to the horizon, and to the center of the station, and also on the adjustments of the instruments, or the application of corrections for certain errors.

The fourth lecture discusses the calculation of the triangles and their errors, and points out the best organization that can be given to the triangulation, and the exactitude which can be expected from it.

The fifth lecture also relates to the calculation and the development of the triangulation, and explains the nature of the geodesical operations for the map of France.

The sixth lecture explains the manner of observing for, and determination of the azimuthal bearing, for the orientation of the triangulation.

The seventh lecture has reference to the convergence of meridians, calculation of rectangular co-ordinates, sundry problems, and geodesical leveling.

The eighth lecture shows in what manner the barometer is made use of for the determination of differences of altitude, the nature of the corrections to be applied to the instrument, and the degree of exactitude to be found in the results of this process.

The ninth lecture points out the order in which geodesical calculations should be performed and the verifications which should be exacted.

The Second Section contains five lectures or exercises, and they have for their object to familiarize the students with the use of the various kinds of instruments employed in carrying on the operations which have been shortly described in the first section.

The Third Section relates to the practical application of the preceding principles, and mostly consists of geodesical applications.

SECOND PART.—COMMON TO THE ARTILLERY AND ENGINEERS.

The First Section consists of lectures given in the amphitheatre, and relates to reflecting instruments, such as the sextant, reflecting circle, and the method of using them, and also on the principles of dialling, and its connection with various problems in astronomy; describes also the different kinds of dials.

SECOND SECTION.—PRACTICAL EXERCISES.

In which the students are called upon, in the presence of the Professor, to adjust the sextant, and to use it in connection with an artificial horizon for the measurement of the angle between any two objects of the altitude of these objects above the horizon, and also the same altitude.

Third Section contains the practical application of the principles enunciated in the preceding sections, in the preparation by the students of two drawings, in which they will exhibit the graphical representation of the hour in terms of the altitude of the sun previously observed, and show the various constructions of a sun-dial, according to the specified conditions based on the observation of the hour angle.

RECAPITULATION FOR THE ENGINEERS.

Lectures.	Number of Lectures.	Credits for Lectures.			Number of Interrogations.
		With application.	Without application.	Total.	
First Part:—Geodesy:					
Lectures with application,	4	6	...	21	1
" without application,	5	...	15		
Second Part:					
Reflecting Instruments,	1	1.5	...	4.5	1
Dialling,	2	3			
Total,	12	10.5	15	25.5	2

Execution of Work.	Number of					Credits.
	Drawings.	Memoirs.	Etats Divers.	Attendances		
				In the Halls.	Out of the Halls.	
First Part:						
Geodesical calculations,...	..	..	1	4	..	20
Exercises of 2½ hours,....	..	..	1	..	5	10
Second Part:						
Drawings of Dialling,....	2	..	..	4	..	20
Exercises of 2½ hours,....	..	..	..	..	1	5
Total,.....	2	..	2	8	6	55

RECAPITULATION OF THE CREDITS OF IMPORTANCE.

Lectures,..... 25 } 80.
Execution of Work,..... 55 }

RECAPITULATION FOR THE ARTILLERY.

Lectures.	Number of Lectures.	Credits for Lectures.			Number of Interrogations.
		With application	Without application	Total.	
Reflecting Instruments,.....	1 }	4.5	..	5	1
Dialling, ...	2 }				
Total,.....	3	4.5	..	5	1

Execution of Works.	Number of				Credits.
	Drawings.	Days.		Memoirs.	
		In the Halls.	Out of the Halls.		
Drawings of Dialling,.....	2	4	..	..	20
Exercises of 2½ hours,.....	..	..	1	..	5
Total,.....	2	4	1	..	25

RECAPITULATION OF THE CREDITS OF IMPORTANCE.

Lectures,..... 5 } 30.
Execution of Works,..... 25 }

VIII.—PROGRAMME OF THE COURSE OF SCIENCES APPLIED TO THE MILITARY ARTS.

		Lectures.
1st part—	Geology,	12
2d "	On the Metallurgy of Iron, on Working in Iron,	6
3d "	Applications of the Working in Iron,	3
4th "	On the Manufacture of Small-arms,	4
5th "	" " of Ordnance,	5
6th "	" " of Powder,	5
7th "	On Pyrotechny,	2
	Total,	37

FIRST PART.—GEOLOGY.

Lecture 1.—Preliminary notions. Definition of geology expressed from its applications. Division in four sections:—1st. Mineralogy. 2d. Paleontology. 3d. Geognosy. 4th. Geogeny. (Only the three first are here treated of.)

First Section.—Mineralogy. Generalities. Distinctive characters of minerals. Fundamental principle of a mineralogical classification. Minerals are distinguished as having characters either exterior, crystalline, chemical, or physical; classification of minerals.

Lecture 2.—First class: Simple bodies forming one of the essential principles of minerals. Genus silica, quartz, sulphur. Second class: Alkali and alkaline salts, potass, soda, &c. Third class: Alkaline earths, and earths. Genus lime. Fourth class: Metals. Iron of various kinds; copper, lead, tin, zinc.

Lecture 3.—Fifth class: Silicates of various kinds. Sixth class: Combustibles, minerals.

Lecture 4.—Description of various rocks. Classification of rocks.

Lecture 5.—Use of rock and stone in the arts, and particularly in the art of construction.

Lecture 6.—On the calcination of calcareous stones, lime-kilns.

Lecture 7.—Manufacture of artificial hydraulic lime, manufacture of bricks, stucco, or cements.

Lecture 8.—Second Section: Paleontology. General division established in zoölogy and botany. General notions relating to the different kinds of animals and vegetables, of which the remains are found in various geological formations. Third section: Geognosy. Lectures 9, 10, 11, 12, occupied with the explanation of the various formations.

SECOND PART.—ON WORKING IN IRON.

Lecture 13.—Preliminary notions. Definitions and general considerations. Characteristics of iron, steel, cast-iron, &c.

Lecture 14.—On iron ore and the various kinds of fluxes.

Lecture 15.—On combustibles. Vegetable combustibles, mineral combustibles.

Lecture 16.—Manufacture of cast-iron. High furnaces, different modes of proceeding with vegetable and mineral combustibles.

Lecture 17.—Manufacture of iron and steel and the different kinds of iron.

THIRD PART.—APPLICATION OF THE WORKING OF IRON.

Lecture 19.—Making of projectiles, carriages for guns and mortars, axle-trees and anchors. Use of cast-iron for artillery. General notions in moulding. Use of wrought-iron and steel. Materials first made use of for the making of projectiles, and in the casting of cannon-balls, &c.

Lecture 20.—On the manufacture of hollow projectiles and the carriages for guns and mortars.

Lecture 31.—On the manufacture of axles and anchors.

FOURTH PART.—ON THE MANUFACTURE OF SMALL-ARMS.

Lecture 22.—Preliminary considerations. Assay of metals. Fire-arms, manufacture of gun-barrels, describing the various details.

Lecture 23.—Bayonets, locks, &c.

Lecture 24.—On the making of stocks. Finishing. Rifling small-arms.

Lecture 25.—Manufacture of sabres, swords, lances, hatchets, cuirasses, and on the preservation, maintenance, and repair of arms.

FIFTH PART.—ON THE MANUFACTURE OF ORDNANCE.

Lecture 26.—Preliminary notions. Metals proper for the manufacture of ordnance. Composition and properties of gun-metal. Wrought and cast-iron ordnance. Moulding generally. Moulding of cannons.

Lecture 27.—Moulding of howitzers. Foundries. Fusion of the metals.

Lectures 28, 29.—Boring. Turning. Carving. Turning of the trunnions, &c. Manufacture and reception of bushes. Insertion and replacement of bushes.

Lecture 30.—Last operations. Proofs and reception of cannon. Chemical operations. Assay and analysis of the metals employed in the casting of gun-metal; proportion of the several ingredients.

SIXTH PART.—ON THE MANUFACTURE OF POWDER.

Lecture 31.—General notions. Various kinds of powder, &c. On saltpetre and sulphur.

Lecture 32.—Charcoal; wood employed; various kinds of charcoal; proceeding followed in making powder in various ways by the pestle.

Lecture 33.—Manufacture by mills, &c.

Lecture 34.—Influence of the proportion of the several ingredients, and of the manner of making it on its various properties. Preservation, inflammation, and combustion.

Lecture 35.—Proofs and reception of powder. Proof of its projectile force. Mortar proof, and various kinds of other proofs to which it is subject. Reception and analysis of powder.

SEVENTH PART.—PYROTECHNY.

Lecture 36.—Preliminary ideas. Objects of the course. Precautions that should be adopted to prevent accident. Mixture of the materials. Manufacture of leaden balls of various kinds. Caps. Fireworks for warlike purposes, used for setting buildings, &c., on fire. Firing cannon and exploding mines.

Lecture 37.—Fireworks employed under various circumstances in war. Signal rockets. For illuminating or setting on fire. For explosions. Petards. On ordinary fireworks.

Works of Application.—The works of application which are connected with the course of science applied to the military arts are as follows:—

1st. Study of samples of mineralogical specimens.
2d. Study of geological maps to be followed by a memoir.
3d. Memoirs on: 1st. Iron and its applications. 2d. Manufacture of cannon. 3d. Manufacture of small-arms and powder.
4th. Out-of-door geological excursions to be followed by memoirs.
5th. Manipulations relative to moulding in earth or sand.
6th. Chemical manipulations.
7th. Pyrotechnic manipulations.

First.—Study of Samples of Mineralogical Specimens.

This study has for its object the determination of the kind of minerals described in the course. It is made in sections of ten or twelve Sub-Lieutenants and by attendances of one hour, each Sub-Lieutenant being called upon to reply at least three times.

Second.—Study of Geological Maps, followed by a Memoir.

The study of geological maps will consist in indicating, by conventional colors, the different geological formations of a lithographical map, and to make a section in a particular direction. The map will be the same for all, and it will be conceived so as to correspond with the geological formation of France, but the sections will differ for each student.

An explanatory memoir will have for its object to call the attention of the Sub-Lieutenants to the most salient facts which will be placed in relief by this study.

One attendance in the halls of study will be devoted to this work.

Third.—Three Memoirs.

Three memoirs on different parts of the course, other than the geological, will be made immediately after the interrogations relative to each section. Particular data will be furnished to each Sub-Lieutenant. Three attendances in the halls of study will be allowed for these memoirs.

Fourth.—Geological Excursions.

Three geological excursions will be made in the environs of Metz by groups of ten or twelve Sub-Lieutenants under the direction of the Professor, and at the period of the out-of-door work, so as not to interfere with the current work in the halls. The first excursion will have for its object the study of the lias and lower oolite, met with in the vicinity of Metz. If the time will admit of it, a reconnaissance will be made to the great oolite at Taumont or at Amanvillers.

The second excursion will be made in the direction of Gorze for the study of the lower oolitic formation and to trace it up to Bradford clay, where an important fault occurs in this direction near to Metz. The study of this fault will be the great object of this excursion.

The third excursion will be made in the direction of Forbach, meeting with the lias, chalk-colored freestone, &c.

Three entire days will be devoted to these excursions, and each Sub-Lieutenant will enter his observations in a note-book, and make a certain number of

sections, and report the results of these excursions in three memoirs in a specified time.

Fifth.—Manipulations relative to Moulding in Earth or Sand.

These mouldings of projectiles will be made by sections of ten or twelve Sub-Lieutenants, two attendances of three hours each being devoted to them, one for ordinary and the other for hollow projectiles.

The manipulations for the moulding of cannon will be executed by the Professor.

All the Sub-Lieutenants will be successively called by sections a certain number of times, in order that they may be enabled to render an account of the different states of advancement of the work.

Programme of practical instruction for the casting of projectiles.

1st attendance. Making shot, &c.

2d attendance. Making hollow projectiles.

Programme of the moulds to be executed by the Professor.

Manufacture of cannon; moulding in earth and the various processes to be carried on.

Sixth.—Chemical Manipulations.

The chemical manipulations are made by sections of ten or twelve Sub-Lieutenants.

Nine attendances of three hours each are employed.

1st. To the determination of the specific gravity and real density of gunpowder and to its analysis.

2d. To two other analyses of gun-metal, iron-ore, &c.

Seventh.—Manipulations in Pyrotechny.

The manipulations in pyrotechny will be made by the whole division, divided into three brigades. Each brigade will be assembled in one of the halls at the School of Pyrotechny, and will execute the different manipulations indicated in the following programme, under the direction of the Professor, and with the assistance of the master artificers of the School of Pyrotechny. Five attendances of three hours will be employed at these manipulations.

PROGRAMME OF THE PRACTICAL INSTRUCTIONS ON MUNITIONS AND FIREWORKS.

1st Attendance. Munitions for small-arms.

Infantry cartridges, { Construction of bullets. " of pouches and caps. " of cartridges.

Cartridges with oblong bullets.

2d Attendance. Ammunition for field guns.

Construction and filling of pouches, packing in wood, &c.

3d Attendance. Ammunition for siege artillery, &c.

Construction and filling of cartridges, &c.

Charging hollow projectiles.

4th Attendance. Fireworks for war purposes.

Construction of matches, quick matches, tubes, fuses for shells and grenades.

Construction of signal rockets.

5th Attendance. Carriage of field ammunition.

Loading and unloading field ammunition chests for cannons, howitzers, and infantry wagons.

Construction of ornamental lances and Roman candles.

RECAPITULATION FOR THE ARTILLERY AND ENGINEERS.

Lectures.—Parts of the Course.	No. of Lectures.	Credits for Lectures.		Total Credits.	No. of Interrogations.	Observations.
		With application, 1h. 5m.	Without application, 3h. 0m.			
1st Part, Geology,.....	12	15	6	20	2	
2d " on Working in Iron,..	6	.....	18	20	1	The first series of interrogations relates to mineralogy.
3d " Applications of working in Iron,.....	3	15	6	10		
4th " Manufacture of Small Arms, ...	4	.....	12	10	1	The second to geognosy.
5th " Manufacture of Cannon,.....	5	.....	15	15	1	
6th " Manufacture of Powder,.....	5	.....	15	15	1	
7th " Pyrotechny,.....	2	3	.....	5		
	37	19.50	72	95	6	

Works of Application.	Number of										Credits.	Observations.
	Studies.	Sketches.	Memoirs.	Exercises.	Manipulations.	Attendances in halls, 4h. 5m.	Attendances out of doors, 6h.	Attendances at the Laboratory.		Attendance at the School of Pyrotechny 3h.		
								1h. to 2h.	of 3h.			
Study of Mineralogical Specimens.....	3	....	....	....	....	....	....	3	.....	.....	5	
Study of Geological Map, followed by a Memoir Map,.....	....	1	....	....	...	1	....	.....	.....	.....	5	
Memoir,.....	....	....	1	....	....	....	....	.....	1	.....	10	
Memoirs on the Metallurgy of Iron, and its—												
1. Application,.....	....	....	1	....	....	1	....	.....	.....	.....	10	
2. Manufacture of cannon	....	....	1	....	....	1	....	.....	.....	.....	10	
3. " " small arms or powder,.....	....	....	1	....	....	1	....	.....	.....	.....	10	
Geological Excursions, followed by Memoirs:												
Excursions,.....	....	....	....	3	....	....	3	.....	.....	.....	20	
Memoirs,.....	....	....	3	....	....	....	....	.....	.....	.....	20	
Manipulations in Moulding	....	....	....	....	2	....	....	.....	2	.....	5	
" Chemistry	....	....	....	....	9	....	....	.....	9	.....	23	
" Pyrotechny	....	....	....	....	5	....	....	.....	.....	3	15	
Total,.....	3	1	7	3	16	4	3	3	12	3	135	

RECAPITULATION OF THE CREDITS OF INFLUENCE.

Lectures,..... 95
Works of Application,.... ..... 135 } 230.

IX. PROGRAMME OF THE COURSE OF APPLIED MECHANICS.

FIRST SECTION.—GENERAL PRINCIPLES.

Lectures 1 and 2.—Short account of the general principles which serve as a base for the application of mechanics to machines, under the compound ratio of their establishment and of the calculation of their effects.

Lecture 3.—General composition of a factory; power, recipient, transmission of movement, tools. General method of calculating the effect of forces in a complete factory.

Lectures 4, 5, and 6.—Theoretical rules and the results of experiments concerning the flow of liquids. (Particular reference is made to the principles which relate to the large orifices of machines moved by water.)

Lecture 7.—Guaging of the volumes and valuation of the dynamical power of water-courses which feed machines.

SECOND SECTION.—MOTOR MACHINES.

Lecture 8.—Theory of the effect of water on hydraulic wheels. Determination of the elements of the calculation.

Lectures 9 to 13.—Application of the general theories to the principal hydraulic recipients. Conditions of the maximum, relative to the useful effect of each kind. Results of experiments, &c. (With reference to turbines, those which are most generally employed in the artillery workshops must be adverted to.)

Lecture 14.—Comparative abstract of the usual properties of various hydraulic "recepteurs." Operations that must be carried on in order to arrive at their results and to their reception in manufactories.

Lecture 15.—Physical ideas relative to the use of the vapor of water as a motive power. Theoretical bases of the calculation of the effects of steam-engines. Force exerted by the compression and expansion of elastic fluids.

Lectures 16 to 18.—Practical notions and results of experiments relating to the effects and to the usual properties of the principal systems of steam-engines in use, as to the employment, reception, and maintenance in workshops.

THIRD SECTION.—RESISTANCE OF MATERIALS.

Lecture 19.—Resistance to compression: 1st, by gradual pressure; 2d, by shock. Results of experience. Application to wooden and cast-iron supports, and to the foundations of machines. Stocks of hammers.

Lecture 20.—Resistance to traction. Application to the shank of a piston, to bolts, chains, cordage, and leather straps. Resistance to flexure. Practical formulæ for calculating the transverse dimensions of the wooden or cast-iron arms of hydraulic wheels, of the catches or sails.

Lecture 21.—Continuation of the resistance to flexure. Practical formula for calculating the dimensions of the several parts of such machines. Cranks, winches, and handles in wood or in metal.

Lecture 21.—Resistance to torsion. Practical formulas. Results of experiments relative to the resistance of wood and metals to boring and turning. Resistance of cast-iron plates to clipping.

FOURTH SECTION.—WORKING MACHINES.

Lectures 23 and 24.—Of blowing machines. General expression of their useful effect. Conditions of the maximum effect. Ventilators; their use in workshops and galleries of mines. Practical bases of their construction. Blowing machines with a piston. Description. Calculation of the effects and results of experiment.

Lectures 25 and 26.—Description and properties of alternative and circular sawing machines. Practical rules for their establishment. Results of experiments concerning the motive power they require, the useful effect obtained, and the resistance of various kinds of wood to the action of the tool. Results of observation relative to the work in shops by hand-saws.

Lectures 27 and 28.—Machines which act by shocks. Practical formula for the calculation of the loss of acting force in the shock. Description and usual properties of various kinds of hammers employed in workshops. Results of experiments proper for serving as the base for the establishment of lever hammers and pestles in powder manufactories. Results of calculation and observation relative to hammers and pestles moved directly or by the transmission of a movement by steam.

Lecture 29.—Grindstones for powder manufactories. Rapidity suitable to the different parts of the work. Means of obtaining it. Calculation of the necessary motive power. Sharpening grindstones for the manufacture of arms. Ventilation.

Lecture 30.—Lathes and drilling bits. Description. Rapidity of movement and form of the tools, according to the nature of the matter and kind of work. Results of experiments concerning the motive force required, and its relation to the useful effect obtained. Composition of a workshop of turning-lathes for an arsenal of artillery.

Lecture 31.—Boring. Machines for cutting and boring. The form of the tool and the rapidity of its action must depend on the nature of the material and the kind of work. Results of experience concerning the motive power required, and its relation to the useful effect obtained, principally for the boring machines of the manufactories of arms and of foundries. Boring machines, disposal of them in an arsenal.

Lecture 32.—Flatteners. Machines for centering, for making screw holes. Descriptions. Different rapidity of the work, dependent on its nature and that of the material. Results of experiments concerning the amount of the motive power and its relation to the useful effect obtained.

FIFTH SECTION.—LECTURES PREPARATORY TO THE WORKS OF APPLICATION.

Lecture 33.—Proceeding to be followed in the preparation of the sketches of a machine. Observations on the effects of machines, their duration, original cost, and cost of maintenance, mode of making, &c. Indications of the difficulties which are met with, and means which should be employed.

Lecture 34.—Project of a factory (specially for the sub-lieutenants of artillery.) Legal conditions respecting the erection of factories. General mode of proceeding with the project. Choice of motor machines dependent on local circumstances and the nature of the work to be performed.

Lecture 35.—(Special for the sub-lieutenants of artillery.) Determination of

the effects supported by the pieces, whose dimensions should be calculated in applying the practical formula of the resistance of materials. Selection of materials.

Lecture 36.—(Special for the sub-lieutenants of artillery.) Principal assemblages of various pieces of machines. Building, foundations, supports of trunnions and pivots.

SECTION SECOND.—WORKS OF APPLICATION.

Survey of Workshops.

This survey of workshops comprehends:—

1st. Figured sketches and observations made on the ground.

2d. Drawing of the whole and of details shaded.

3d. A memoir containing an accurate description of the machines and workshops, the calculation of the dynamical effect, the exposition of the mode of fabrication, and, in general, the results and consequences of the observations made on the spot. It must be executed by each, conformably with the particular programme, and to the instruction which will be given to him. He is allowed for this work thirty-four days.

Project of Machines.

This work, executed immediately following the preceding, by the sub-lieutenants of artillery only, has exclusively for its object the establishment of a workshop for the service of the artillery, comprehending the driving machines and the principal operators; or, if there be time, the improvement of the workshops of the same arm, described in the preceding work. This project must be executed conformably to the particular programme given to each sub-lieutenant. It comprehends; 1, sheet of drawings: 2, a memoir. Twenty-six days are allowed for this work.

RECAPITULATION.

Oral Instruction—Parts of the Course.	Artillery.					Engineers.				
	No. of Lectures.	Credits for Lectures.		Total Credits.	No. of Interrogations.	No. of Lectures.	Credits for Lectures.		Total Credits.	No. of Interrogations.
		With application.	Without application.				With application.	Without application.		
1st Section—General Principles,	7	6	9	15	1	7	6	9	15	1
2d Sec.—Driving Machines,	11	12	9	21	1	11	12	9	21	1
3d " Resistance of materials,	4	5	3	8	.....	4	5	3	8	...
4th Sec.—Working Machines,	10	15	....	15	1	10	15	....	15	1
5th " Lectures preparatory to the works of application,	4	6	....	6	.....	1	1.50	....	1.50	...
Total.....	36	44	21	65	3	33	39.50	21	60.50	3

RECAPITULATION.

Works of Application.	Number of					Number of				
	Sheets of drawings.	Memoirs.	Attendances In the Halls.	Attendances Out-of-doors.	Credits.	Sheets of drawings.	Memoirs.	Attendances In the Halls.	Attendances Out-of-doors.	Credits.
Survey of Workshops:										
Figured sketches and observations,	1 note book.	....	....	8	65	1 note book.	.....	....	8	65
Shaded drawings,	1	....	22	....	100	1	.....	22	....	100
Memoir,	.....	1	4	....	40	.....	1	4	....	40
Project of Machines:										
Calculations and drawings,	1	....	20	....	90	.....	.....	....	....	.....
Preparation of memoir,	.....	1	6	....	60	.....	.....	....	....	.....
Total,	1 note book 2 sheets	2	52	8	355	1 note book 2 sheets	1	26	8	205

RECAPITULATION.

	Artillery.	Engineers.
Credits for lectures assigned to the interrogations,	65	60
Credits for works of application,	355	205
	420	265

X.—PROGRAMME OF THE COURSE ON CONSTRUCTION.

The course on construction is divided into four parts.

The first part relates to the elements of masonry and the principles which should regulate the form, dimensions, and the construction of walls, and the different parts of buildings; it contains eighteen lectures.

The second part is devoted to the architecture of military buildings—twelve lectures.

The third part supplies the theory of the stability of construction, and is divided into—

1st section, relating to the resistance of materials—six lectures.

2d " to the stability of walls of revetments and arches—nine lectures.

The fourth part applies to constructions in water—twenty lectures.

The course is very nearly the same for the Artillery as for the Engineers.

ELEMENTS OF MASONRY, ETC.

Lectures 1, 2, and 3.—Relate to the elements of which masonry is composed, such as the different kinds of stones, usual dimensions, manner in which good stone may be known; bricks, lime, cement, sand, mortar, stucco, mastic plaster, asphalte, &c., and to the general considerations relating to foundations, and the different kinds of walls under various circumstances.

Lecture 4.—Treats of sustaining walls and the probable effects of the pressure of the earth. Of the conditions which must be fulfilled to insure stability. Various formulæ on the subject. Details of construction and on the proper material to be used.

Lecture 5.—Refers to the manner of facing masonry. Openings in walls, windows. Partition-walls.

Lecture 6.—On cylindrical arches, vaults, key-stones. Formulæ for the calculation of the thickness of piers of an arch or vault. Construction and use of tables for the calculation of the thickness. Construction of arches and vaults in different materials.

Lecture 7.—Arches continued, flat arches, plate bands, &c.

Lecture 8.—On the woods used in construction. On the influence of the soil on its quality. Characteristics of good wood. Preservation of wood. Proper wood for constructions.

Lecture 9.—Flooring. Beams. Girders. Joists. Ceilings.

Lecture 10.—Staircases, conditions respecting. Construction of different kinds of staircases, part of masonry, wood, &c.; steps. Construction of landing-places, &c.

Lectures 11 and 12.—Roofs in carpentry. Conditions which should be satisfied. Composition of the roof of a building. On the different kinds of roofs.

Lecture 13.—On the different ways of joining pieces of wood or timber together.

Lecture 14.—On permanent kinds of roofing. Conditions which should be fulfilled by good roofing. Composition of roofing. Tiles, lathing, cut slates, ridge tiles, hollow tiles, Dutch tiles. On slate roofing. Metallic roofing. Metal mostly used. Precautions to be taken with reference to all metal roofing.

Lecture 15.—Details relating to inhabited buildings. Cellars. Privies. Drainage. Chimneys; cause of their smoking. Most favorable forms of the flues, pipes. Bake-house, hearth.

Lecture 16.—On joinery and locksmiths' work. Flooring of different kinds. Doors. Camp-beds. Racks and mangers in stables. Shutters.

Lecture 17.—Apparatus for heating and for cooking food. Hearth, ash-pan. Grate-flues. Amount of surface to be given to heating apparatus. Furnace of kitchens in barracks. Summary notions on the heating and ventilating of buildings. Calorifères with hot air, steam, and hot water.

Lecture 18.—Plan of a building. Projections adopted for the representation of a building. Plans, sections, and elevations. Order in which the measurements should be made, and the sketch prepared. Height at which the horizontal plane of projections should pass, &c.

SECOND PART.—ARCHITECTURE OF MILITARY BUILDINGS.

Lecture 1.—Decoration, without making use of the orders of architecture. Principal conditions relating to decoration. Symmetry, regularity, simplicity, unity, and apparent solidity. Proper character. Proportions of the façades. Height of the stories. Basements. Horizontal chains or fillets. Vertical chains and pilasters. Proportions of the doors and windows. Arcades and arched windows. Cornices, pediments.

Lecture 2.—Distribution of buildings. Considerations that should have weight in the distribution. Number composing the edifice. Circumstances that guide in the disposal of masses. Conditions that should be satisfied in placing a building. Locality and suitable dimensions. Relations that should exist between them. Interior and exterior communications. Stories on the same floor.

Position of the large rooms. Separation of the rooms. Position and arrangement of staircases. Verification of stability.

Lecture 3.—Conditions to be fulfilled in the distribution of the principal military establishments. Arsenals. Polygons for drill. Military establishments to the School of Bridges.

Lecture 4.—Foundries. Manufacture of arms.

Lecture 5.—Refining saltpetre. Powder. Powder magazines. Details relative to the construction of lightning conductors.

Lecture 6.—Infantry and cavalry barracks.

Lecture 7.—Hospitals. Military prisons and penitentiaries.

Lecture 8.—Storehouse for corn. Store-pits. Storehouse for fodder. Preserving houses.

Lecture 9.—Cisterns. Filtration.

Lecture 10.—Military tribunals. Guard-house. Gates of cities. Hotels and dwelling-houses. Officers' quarters.

Lecture 11.—Preparatory to the execution of a project for a building. Method of proceeding. Composition of the sketch; approximate surface of all the locality; separation into symmetrical groups in the case of several buildings; number of stories; surface of the ground floor; length and breadth of the building between its walls; distribution of each story; verification of the relation between the stories. Elevation of the building. Sketches. Memoir. General details, and details of execution.

Lecture 12.—Discussion before the abstraction of the measurements and the preparation of the estimate of the building.

THIRD PART.—FIRST SECTION: ON THE RESISTANCE OF MATERIALS.

1. Resistance of prismatic bodies to extension and compression. Elasticity of bodies. Modulus of elasticity. Limits of permanent efforts. Resistance to extension and compression of stone, bricks, and analogous materials; also of wood and metals. Applications.

2. Transverse resistance. Some cases in which it is brought into play. Results of experience. Resistance of bodies submitted to the effects of transversal flexure. Results of experience and conventions. Conditions of equilibrium of bodies submitted to efforts directly transversal to their length. Direction and value of molecular efforts. Equation of the axis of the body. Equation of the squaring. Discussion of these equations.

3. Geometrical method for determining the inertia. Application to the research for the inertia of various sections. Applications of general equations of equilibrium and of squaring to straight pieces.

1st. A horizontal piece set in a frame at one extremity, and subjected to a weight acting at the other extremity, with a uniform vertical effect.

2d. Horizontal beam placed upon two supports, and subjected to a weight acting at its center, and with a uniform vertical effect.

3d. Beam placed horizontally on two supports, and having two equal weights symmetrically placed with respect to its center.

4th. Beam placed horizontally on two supports, and subjected to a weight acting at any point whatever throughout its length.

5th. Horizontal beam fixed at both its extremities, and subjected to a weight acting at its center with an equal vertical effect.

6th. Horizontal beam placed on three points of support, at unequal distances, and weighted with two weights acting at the middle of the intervals between the supports.

7th. Vertical beam fixed at the foot, and charged with a weight acting at a certain distance from the axis of the beam.

5. Solids of equal resistances. Most suitable form for cast girders. Applications of the formula of equilibrium and squaring to various kinds of carpentry.

6. On polygonal roofs. Conditions respecting them. Arched roofs, pressure, &c. On the stability of walls required to resist the pressure of roofs.

SECOND SECTION: ON THE STABILITY OF REVETMENT WALLS AND ARCHES.

7. On the pressure of earth. Explanation of the theory on Coulomb's system. Investigation of the pressure of earth by analysis. Hypothesis necessary in order to simplify the calculations. General formula of the value of the pressure, &c. Equations of stability and equilibrium under the hypothesis of slipping and rolling.

8. Simplification of the general equations of equilibrium in three particular cases. Determination of the co-efficient of stability in Vauban's profile. M. Poncelet's formula for calculating the thickness of revetment walls with perpendicular face. Transformation of the profile of a revetment to another of equal stability. Vauban's counterforts, &c.

9. Geometrical method for determining the pressure of earth, whatever may be the profile of the wall and of the earth, taking into account the friction of the earth on masonry. Geometrical determination of the amount of the pressure. Proceeding for the determination, by geometry, of the thickness of a revetment wall at the level of the exterior ground.

10. On buttresses. Geometrical determination of the buttressing of earth, and of its momentum. Simplification of the geometrical constructions of the pressure, of the buttressing, and of their moments under certain hypotheses.

11. Points of application of the pressure and of the buttress. 1st. In the case of a terrace sloping less than the natural slope of the ground. 2d. In the case of the ordinary revetments of fortification.

On the stability of the foundations of revetment walls.

Compressible soil. The resultant of all the forces should pass through the center of the base. Size of the footing of the wall or depth of the foundations to arrive at the result. Possibility of the wall slipping over the base of the foundations. Use of the buttress to prevent this movement. Graphical method to determine the depth of the foundations. Depth of the foundations in unstable soil.

12. Pressure of arches. Case of cylindrical arches. Explanation of the theory of the pressure of arches. Point of application of the pressure in the five modes of possible rupture. Expression for the pressures and resistances by rolling or slipping. Proceeding to be followed to find by calculation the pressures and resistances.

13. Geometrical determination of the pressures and resistances by rolling. Explanation of the solution of this question. Construction of lines proportional to the surfaces of the voussoirs. 1st. In the case of an arch. Extrados without coping or additional weight. 2d. In that of an arch with extrados in the form of coping, and with or without additional weight. Construction of the

verticals passing through the center of gravity of the voussoirs. Abstract of the operations to be performed. Determination by geometrical means of the pressure and resistance against slipping.

14. Co-efficient of stability of arches from the springing. Manner of finding the outline of an arch for a certain given co-efficient. Stability of a cylindrical arch on its piers. Thickness of the piers. Considerations relative to the value of the co-efficient of stability. Stability of an arch on the base of its foundations. Filling in and depth of the foundations of piers.

Extension of the geometrical methods serving for the determinations of the pressures and thicknesses of piers in case of cross vaulting, arcades, and spherical vaulting.

15. Investigation by analysis of the pressures and resistances of an arch.

1st. Hypothesis of a plat-band; stability at the springing charge necessary on the coussinet; stability of the plat-band on its piers; thickness of the piers. Squaring of a tie-beam of iron which annihilates the pressure.

2d. Hypothesis of a semicircular vaulting with arched extrados. Pressures and resistances. In similar arches the pressure is proportional to the square of the radius.

FOURTH PART.—HYDRAULIC CONSTRUCTION.

1st. Classification of ground on which it may be necessary to place a foundation. Soundings. Their object. Various kinds of sounding line. Dams in earth, and in wood and earth combined. Case of an unstable foundation. Construction on rock. Thickness of dams and of the clay work. General disposition of a dam. Bottom-springs. Means of choking or smothering them or of diverting them. Use of sunk dams. Service bridges. Their height and disposition. Railways in great constructions. Their disposition.

2d. Summary review of draining or pumping machines. Choice between the different methods of draining. Table of the useful effect of such machines.

Pile driving. Pile driving machine with hand ropes. Preparation of the pile and operation of driving. Pile driving machine with catch. Choice between the two kinds of pile driving machines. Precautions to be taken in the driving of piles. Distribution of piles, the space to be left between them, and the squaring of them. Disposition and driving of planks. Method of drawing up piles and planking. Execution of a foundation on piles. Driving stakes out of water. Machine for squaring piles.

3d. Parafouilles. Their object and construction.

Foundations in mortar under water. Preparation and immersion of the mortar. Examples.

Thickness of sunk dams with the enceint in mortar.

4th. Foundation frames and platforms. Their object and their construction. Preparation of the foundation frames in masonry.

Foundation by packing.

Foundation by coffer-dams. Details of a coffer-dam.

5th. Foundations on solid gravel. Properties of gravel. Case where it is advantageous to make use of gravel. Examples.

Foundations on sunk wooden piles, in gravel, and in gravel and mortar.

Foundation on pillars built in masonry.

Foundations on quicksand.

Species of foundation to adopt according to the nature of the ground.

6th. Banks of reservoirs. Conditions which should be fulfilled in their establishment. Banks in earth; their profile; revetments to protect them; the wet slope; sort of remblai; precautions which exact a large remblai. Banks in remblai and sustaining walls combined. Banks entirely in masonry; movements observed in walls; most suitable profile. Comparison between banks in earth and masonry. Works which are employed in connection with banks of reservoirs. Dikes of inundations. Their profile; defense of their slope against the action of water; their establishment and works in connection with them.

7th. Batardeaux in the ditches of strong places. Situation; profile; details of construction. Weirs. Their object; effect of a weir in a current. Advantages of the wedge or circular form. Height to give to a weir; and longitudinal form of the swelling occasioned by a horizontal dam. Construction of weirs with vertical walls, with a long slope down the stream. Injuries to which weirs are liable. Profile to adopt according to the nature of the ground.

8th. Sluice-dams, their object; form of the piles; distance apart, and dimensions. Details of construction. Various kinds of apparatus for opening and shutting sluice-dams. Play of a revolving gate. Calculation of the dimensions of the two half sluice gates and of the wicket. Carpentry of a revolving gate. Movable dams with iron wickets. Modifications to render them applicable to the retention of water at a greater height than 2.80 meters.

9th. Navigable locks. Canal lock; its management; form of the chamber; profile of the cheeks. Trace of the pier on which the gates work. Means of filling and emptying the chambers. Means of raising the paddle-valves. Wood-work of the gates sheathed in timber. Planes. Details of the pivots, collars and rollers. Arrangements for the management of the sheathed gates.

10th. Gates sheathed in wood; curves. Ties of cast-iron, and lining in wood or sheet-iron. Cast-iron gates.

River Navigation.—Advantages and disadvantages of water transit. Conditions of a navigable river. Works for the improvement of the navigation on a river.

Artificial Navigation.—Classification of canals. Conditions which determine the best position for a summit level. Search after a minimum of elevation. Expenditure of water at the summit level.

11th. Principal processes employed to economise the water in passing through a lock. Profile of a navigable canal.

Deep cuttings; their profile. Great landslips and means of remedying them.

Tunnels; their profile. Piercing of a tunnel.

12th. Bridges in masonry. Position; breadth of the roadway; outlet to be left for the water; size and form of the arches; trace of the surbased arches on more than five centers. Expansion of the bridge-heads. Profile of the arch. Thickness of the piles and abutments. Apparatus for the arches and bridge-heads. Parts above the arches. Leveling with the banks. Fixed and movable centerings. Removal of the centerings of arches.

13th. *Wooden Bridges* composed of straight pieces. Arrangement of the stakes and starlings. Different construction of the openings according to their span. Arrangement of the platform.

American Bridges.—Arrangement of the earliest form of bridge on Town's system. Height of the trusses constructed in the form of trellis-work. Modi-

fications introduced to increase the resistance of the bridge. Calculation of the resistance of the trusses.

Arched frame-work of bridges. Composition of the arches. Junction of the straight beams with the arches.

Cast-iron Bridges.—Different systems. General principles of their construction.

Aqueducts in masonry; in cast-iron.

14th. *Suspension Bridges.*—Equation of the curve of the chains and construction of this curve. Tension supported by the suspension cables, their thickness. Influence of the length of the flèche upon the tension of the cables. Inconveniences resulting from a long flèche. Vibrations and means of diminishing them. Limits of length of the flèche. Length of the curve of suspension. Causes operating to vary this length; means of obviating the effects produced by them. Length of the suspension rods. Number of supports to be adopted. Thickness of the piles. Points at which the fixing cables are to be attached. Advantages and disadvantages of chains composed of bars and of cables of iron wire. Some details of construction.

15th. *Drawbridges.*—Conditions which they must satisfy. General principle of their balance.

Drawbridges with Flyers.—Special theory of this bridge. Reduction of it to practice. Alteration of equilibrium and means of remedying it.

Disadvantages of the drawbridge with flyers.

16th. Spiral drawbridge of Captain Berché. Trace of the spiral. Determination of the radius of the chain-roller, and of the greatest radius of the spiral.

17th. Drawbridges with variable counterbalances, invented by M. Poncelet. Construction of the chains of the counterbalance. Establishment of the leverage. Calculation of the counterbalances for the special case of the pulleys in front corresponding to the axis of the platform. Influence of the nature of the chains. Method of allowing for the weight of the small chains. Definitive construction of the chains of the counterbalance. Provision of loose cords.

18th. Succinct ideas upon the motion of the sea, and its action on the shore.

Undulating movement. Height of the waves, and depth at which the agitation is perceptible. Effects of the waves on the coasts. Tides; spring-tides; neap-tides. Height of tides and hour of flood. General currents. Action of the sea on its shores. Protection of level and steep shores.

19th. Sea-ports. Requisites of a good port. Ports in the Mediterranean. Conditions of a good roadstead. Moles and breakwaters. Ocean ports, channel tide-dock, floating dock, and sluice of floating dock, laying-up dock, and sluice for the ditch of fortifications. General arrangement of a harbor.

20th. Construction of moles. Stones dropped for foundations. Profile of a loose heap. Volume of the materials which insure their stability. Settling of masonry resting on a heap. Instances of masonry constructed at sea. 1. Wall of Cherbourg. 2. Fort Boyard.

Piers.—Direction, length, form of interval between, and profile of piers. Their construction. Passages reserved through piers.

RECAPITULATION.

First Part.—Parts of Buildings,		18
Second Part.—Architecture of Military Buildings,		12
Third Part.—	First Section. Resistance of Materials, ... 6	15
	Second Section. Stability of Constructions, ... 9	
Fourth Part.—Hydraulic Constructions,		20
Total,		65

WORKS OF APPLICATION.

Name of work.	No. Days allowed for execution of work to Students of				Subject employed on.	Observations.
	Artillery.		Engineers.			
Survey of a Building:					Representation of an existing building or a part of a building by means of plans, sections, and elevations.	Each day is equivalent to 4½ hours' work.
Sketch (out-of-door work,).	8		8			The sketches are executed to scales approximating to one-fiftieth for the whole drawing, of one-twentieth for the large details, and of ½ to ⅛ for the minute details.
Drawing,.....	21	31	21	31		
Memoir,.....	2		2		The memoir contains an accurate and critical description of the distribution, construction, and decoration of the building.	
						The drawing prepared from the sketches is made on the scale of 1-100th.
Project for a Building:					Study and preparation of a project of a building, in accordance with certain given data.	This work, common to the students of the two arms, is an application of the first part of the course.
Sketch, (first study in pencil.)	12		12		The sketches, the result of the first study, are made in pencil; the drawing is the fair copy of the sketch, modified as may be necessary.	The scale for the drawing is in general 1-200th for the plans and elevations, and 1-100th for the sections. It is restricted by the condition that the whole of the drawings should be given on a single sheet of paper.
Drawing, (fair copy,).....	18		18			
Details,.....	4	42	4	42		
Memoir, ...	4		4		The memoir contains an explanation of the rules and principles which must be observed in the construction of buildings, and the grounds on which the dispositions contained in the building have been adopted.	The details need only occupy half a sheet of paper, and its scales must depend on the size of the objects to be represented.
Abstraction of Measurements and Estimates	4		4		The abstraction of the measurements and their reduction to the proper elements, and the estimates, are prepared in conformity to the instructions laid down for the Engineer Service in towns: these supply the estimated cost of the construction of the building according to the project.	The project for a building is an application of the two first parts of the course, as well as of the 1st section of the 3d part.
Diagram of the Stability:					Determination of the profile for a revetment wall, according to certain conditions. Verification of the stability of an arch, and calculation of the pier supporting this arch.	The drawing is executed to the scale of 1-100th. This work is an application of the 2d section of the 3d part.
Drawing,.....	6	9	6	9		
Memoir, ...	3		3		In the memoir a short explanation is given of the theory relating to the strength of revetment walls and arches, as well as the results of the application of these principles to the particular case.	
Project for an Hydraulic construction:					Study and composition of a project for a great work of art on certain given data.	The scale of the drawing is chosen in such a manner that the project may be placed on a single sheet; generally it is 1-200th, or smaller.
Sketches,.....	10		12			
Drawing,.....	15	28	18	34		
Memoir,.....	3		4		In the memoir an explanation is given of the principles and the results of the theories which are to be applied in making this project The arrangements adopted in the project are discussed for the foundation and all other parts of the construction.	The project of a hydraulic construction is an application of the 1st section of the 3d part as well as of the 4th part of the course.
Total,....	110		116			

1st. Lectures.—Parts of the Course.	Artillery.					Engineers.					Observations.
	No. Lectures.	Credits for Lectures.			No. Interrogations.	No. Lectures.	Credits for Lectures.			No. Interrogations.	
		With application.	Without application	Total.			With application.	Without application	Total.		
1st Part: Elements of Masonry, form and dimensions of the different parts of buildings,.....	18	24*	6	30	2	18	24*	6	30	2	*A lecture with application is equivalent to 1½ hours of work, and a lecture without application is equal to 3 hours.
2d Part: Architecture of military buildings,....	12	18	.....	18	1	12	18	.....	18	1	
3d Part: Theory respecting stability: 1st section—Resistance of materials,	6	6	6	12	1	6	6	6	12	1	
2d section—Stability of revetment walls and arches,.	9	10.5	6	16.5	1	9	10.5	6	16.5	1	
4th Part: Hydraulic Constructions,.....	20	24	12	36	1	20	24	12	36	1	
Total,.....	65	82	30	112	6	65	82	30	112	6	

2d. Execution of the Work.	Artillery. Number of						Engineers. Number of						Observations.
	Drawings and Sketches.	Memoirs.	Various.	Attendances in halls 4½ hours.	Attend'nces out of doors, 6 h.	Credits.	Drawings and Sketches.	Memoirs.	Various.	Attendances in halls 4½ hours.	Attend'nces out of doors 6 h.	Credits.	
Plan of a Building:													
Sketches (pen,)....	1	....	....	....	8	50	1	....	....	....	8	50†	
Drawing,.....	1	....	....	21	....	95	1	....	....	21	....	95	
Memoirs,.....	....	1	....	2	....	20	....	1	....	2	....	20‡	
Project of a Building:													
Sketch,.....	1	....	....	12	....	55	1	....	....	12	....	55	
Drawing,.....	1	....	....	18	....	80	1	....	....	18	....	80	
Detail,.....	1	....	....	4	....	20	1	....	....	4	....	20	
Memoir,.....	....	1	....	4	....	35	....	1	....	4	....	35	
Abstraction of quantities and estimates,	....	....	1	4	....	20	....	....	1	4	....	20	
Diagram of Stability.													
Drawing,.....	1	....	....	6	....	25	1	....	....	6	....	25	
Memoir,.....	....	1	....	3	....	25	....	1	....	3	....	25	
Project of an Hydraulic construction.													
Sketch,.....	1	....	....	10	....	45	1	....	....	12	....	55	
Drawing,.....	1	....	....	15	....	70	1	....	....	18	....	80	
Memoir,.....	....	1	....	3	....	25	....	1	....	4	....	35	
Total,.....	8	4	1	102	8	565	8	4	1	108	8	595	

† Of which 20 is for the out-of-door work, and 30 for the sketch.
‡ The time allowed for the preparation of the memoirs in the halls should be doubled, in order to take an account of the correction out of the halls of study.

RECAPITULATION OF THE CREDITS OF INFLUENCE FOR THE COURSE.

Artillery,	Lectures,.....112 Execution of Work,.....565	677,	or about 680.
Engineers,	Lectures,.....112 Execution of Work,.....595	707,	or about 710.

XI.—PROGRAMME OF THE COURSE IN THE GERMAN LANGUAGE.

SECOND DIVISION.—FIRST YEAR'S STUDY.

Number of Lectures, 50.

Grammar and composition during the 25 Lectures forming the odd numbers.

Oral translations of German authors. Phraseology. Lecture on idioms, founded on the passages which have been translated and given in the form of conversation during the first half of the 25 Lectures forming the even numbers.

Dialogues and conversations, on various subjects of every-day life, such as are particularly useful to an officer traveling in Germany, carried on during the second half of the Lectures of the even numbers.

FIRST DIVISION.—SECOND YEAR'S STUDY.

Number of Lectures, 100.

Translations of German authors, and conversations in German on the passages translated, during fifty Lectures, reckoning the odd numbers.

Military reconnaissances, in the form of a dialogue in German and in French, during the first half of the fifty Lectures, even numbers.

Translation of French into German: 1st, Narratives; 2d, Historical and descriptive fragments; 3d, Dramatic scenes; 4th, Epistolary style, during the second half of the fifty Lectures, even numbers.

At the close of the second year, the Sub-Lieutenants give in a composition on a certain subject.

The Sub-Lieutenants most advanced are not obliged to follow the course in German, but they should make translations of articles taken from German military works. These translations, after having been corrected, are deposited in the Library of the School.

Abstract of the course in German:—

1st year's study,..... 50 Lectures.
2d " " ..... 100 "

Total, ... 150 at ½ hour each—112. 3 0.
Credits of influence,..... 110.

XII.—PROGRAMME OF A SHAM SIEGE.—(Common to the Artillery and Engineers.)

FIRST SECTION.—PRELIMINARY MEASURES.

ART. I.—*Commission charged to study the Project for a Sham Siege.*

A Commission is charged with drawing up and presenting to the General commanding the School a project for a sham siege. This is composed of:—

The Colonel second in command of the School,....President.
The Major of Artillery,.....
The Major of Engineers,..... } Members.
The Professor of Artillery,.....
The Professor of Fortification,.....
Clerk.

The Professors of Artillery and Fortification may be replaced by the Assistant Professors.

The General Commandant of the School decides in a Council of Instruction on the dispositions to be adopted for the project of a sham siege.

ART. II.—*Preparatory Lectures.*

By the Professor of Military Art, ... 2

1st. Considerations relating to the fortress of Metz. Circumstances which might bring on a siege of it. Force of the garrison and of the besieging army. Investment.

2d. Trace of the lines of circumvallation and of countervallation.

By the Professor of Topography, ... 1

Execution of the second reconnaissance plan (*memoire*,) (1 lecture.)

1st. Measure of the base. Plan of the ground of the attack. Construction of the plans. Plans of the work executed.

By the Professor of Permanent Fortification, ... 2

1st. Discussion on the points of attack Organization of the *personnel* and *matériel* of the Engineers of the besieging army and of the garrison.

2d. General progress of attack, and general dispositions of defense.

By the Professor of Artillery, ... 2

1st. Composition of the personnel and matéreil of the Artillery of the besieging army. Transport of the siege equipage.

2d. General dispositions of the artillery in the attack and defense.

SECOND SECTION.—COMPOSITION OF THE PERSONNEL.

Director of the Siege.—The General Commandant of the School.

Chief of the Staff.—The Colonel second in command of the School.

Chief of the Artillery Service.—The Major of Artillery attached to the Staff.

Director of the Park of Artillery.—This may be given to the preceding.

Chief of the Engineer Service.—The Major of the Engineers attached to the Staff of the School.

Director of the Engineer Park.—This may be given to the preceding.

Major of the Trenches.—A Captain. Chiefs of Attacks. Captains.

Chiefs of Brigades.—Named by the General Commandant of the Siege.

THIRD SECTION.—CONFERENCES.

Before proceeding to the ground, the sub-lieutenants assist at conferences which are held for the purpose of explaining to them the successions of the several operations of the siege, as well as upon the traces which they have to execute. These conferences, eight in number, are divided as follows:—

The Chief of the Artillery Service will hold 4 conferences, and
The Chief of the Engineer Service " 4 "

FOURTH SECTION.—TRACING OF LINES AND TOPOGRAPHICAL WORK.

1st. The second reconnaissance survey (comprised in the course of topography.) Tracing of lines; one day is allowed for this work.

2d. "Director" plan. The execution of this plan comprises out-of-door work and drawing. The out-of-door work includes the measurement of one or many bases, the observation of the angles which are formed by this base, and the direction of certain remarkable points in the city and fortification, and the formation of a net-work of triangulation, intended to co-ordinate the surveys of the details.

The work of constructing the plan consists in laying down, day by day, the surveys of the details of the ground, as well as of the traces executed. Five

days are allowed for the execution of the topographical work, which precedes the opening of the trenches. The Director Plan is kept close up during the whole duration of the siege.

3d. Itineraries and sketches (comprised in the course of topography.)

The Professor of Topography directs the whole of the surveys and the execution of the Director Plan.

FIFTH SECTION.—TRACING OF THE WORKS OF ATTACK, AND ACTUAL EXECUTION IN FULL RELIEF OF CERTAIN WORKS.

The sub-lieutenants, divided into brigades, trace the works of the siege, under the direction of the officers of the staff, and take part in the superintendence of the works executed in full relief when the exigencies of the service will permit the chief of the Artillery Service and the Colonel of the Regiment of Engineers to place workmen at the disposal of the General Commandant of the School. Six days are appropriated to this work.

SIXTH SECTION.—WORK IN THE HALLS OF STUDY.

The work in the Halls of Study consists of:—

1st. A memoir on the sham siege, which memoir must be approved by the General Commandant of the School.

2d. Of a sketch representing one of the works traced or executed in full relief. These works in the Halls are performed during the interval of the attendances devoted to out-of-door work. Two days are appropriated to the preparation of the memoir, and two to the execution of the sketch. This time is included in the eleven days allowed to the sham siege.

RECAPITULATION FOR THE ARTILLERY AND ENGINEERS.

Lectures and Conferences.	No. of Lectures or Conferences.	Credits for Lectures or Conferences.			No. of Questions.	Observations.
		Lectures.	Conferences.	Total.		
By the Professor of Military Art,	2	3	..	3	2	One series of questions by the Chief of the Artillery Service, as to what relates to that arm. One series of questions by the Chief of the Engineer Service, as to what relates to that arm. A Credit of 11 is assigned to each series of questions.
" of Topography,	1	1½	..	1½		
" of Permanent Fortification,	2	3	..	3		
" of Artillery,....	2	3	..	3		
Conferences by the Chief of the Service, of Artillery,...	4	..	6	6		
Conferences by the Chief of the Service, of Engineers,..	4	..	6	6		
Total,.....	15	10½	12	22½	2	

Works of Application.	Number of Drawings.	Number of Memoirs.	Attendances out of doors. of 4½h.	Attendances out of doors. of 8 h.	Attendances in the Halls.	Credits.	Observations.
2d Reconnaissance Plan (Memoir,)							
Topographical Work,.....	..	..	4	..	..	20	Credits given by the Professor of Topography.
Itinerary and Sketch (Memoir,)	..	..	..	..	..	..	
Plan "Director,"	..	..	..	..	1	5	
Tracing of Lines,.....	..	..	..	1	..	10	Credits given by the Captains of the Staff, Chiefs of Brigades.
Tracing of Works of Attack and of Defense,.....	..	..	6	..	..	25	
Sketch,.....	1	..	..	..	2	1	Credits given by the Chiefs of the Service of the Artillery and Engineers.
Memoir,.....	..	1	..	..	2	2	
Total,.....	1	1	10	1	5	90	

XIII.—PROGRAMME OF THE COURSE ON THE VETERINARY ART.

FIRST PART.—INTERIOR OF THE HORSE.

Lecture 1.—Classification and nomenclature of the various matters which constitute the horse. Skeleton (head and body.)

Lecture 2.—Skeleton (limbs.) Mechanical importance of the skeleton. Nomenclature and use of the muscles. Cellular and fatty tissues, grease, skin. Insensible perspiration.

Lecture 3.—Functions for maintenance. Arteries of the nerves. Animal heat.

Lecture 4.—On various functions.

SECOND PART.—EXTERIOR OF THE HORSE.

Lecture 5.—Proportions. Equilibrium. Description and importance of the natural beauties and defects of the head and region of the throat.

Lecture 6.—Description and importance of the other parts of the horse. Blemishes. Soft tumors.

Lecture 7.—Osseous tumors. Various accidents. Temperaments. Description of clothing, &c.

Lecture 8.—Data respecting horses.

Lecture 9.—To know the age. On various bad habits. Examination of the eyes; their diseases.

Lecture 10.—Defective paces, &c. Draught and pack horses. Mules.

Lecture 11.—Stud and remounts. Races.

Lecture 12.—Vicious horses, and different bits. Manner of bitting a horse. On grooms and punishment.

THIRD PART.—ON THE HEALTH OF THE HORSE.

Lecture 13.—Examination of the foot, and shoeing with the hot shoe.

Lecture 14.—Shoeing with the cold shoe. Different kinds of horse-shoe, &c.

Lecture 15.—On stables. Food. Rations.

Lecture 16.—Description and nomenclature of the saddle. Harness and pack. Various saddles.

Lecture 17.—On work and rest. Horse and mule on the road and in bivouac. On diseases and accidents.

Abstract of the course:—

Interior of the horse, 4 Exterior, ... 6 Health, ... 7	17 lectures at 1½ hours.	Total time, 25½ hours. Credits, 25.

The instruction on horseback can, under certain circumstances, be considered as connected with this course; and questions are asked during the time when the sub-lieutenants are not engaged in actual riding exercise. This instruction is described under the head of Practical Military Instruction; it comprises at the maximum 272 attendances, and its credit of influence is valued at 240.

ARTILLERY AND ENGINEERS' REGIMENTAL SCHOOLS.

I. ARTILLERY REGIMENTAL SCHOOLS.

THESE are intended for the theoretical and practical instruction of officers, *sous-officiers*, and gunners.

Each School is under the orders of the General of Brigade commanding the Artillery in the military division in which it is situated.

Independent of the general officer, the school has the following staff:—

A Lieutenant (associated assistant to the General.)
A Professor of Sciences, applying more particularly to the Artillery.
A Professor of Fortification, of drawing, and construction of buildings.
Two *Gardes* of Artillery (one of the first, and the other of the second class.)

There are, in addition, attached to each school the number of inferior officers (captains, lieutenants, or *sous-lieutenants*) required for carrying on the theoretical courses, which are not placed under the direction of the professors.

A captain of the first class, assisted by two first lieutenants, is the director of the park of the school. Another captain, also of the first class, but taken from the regiment of Pontooneers, has the direction of that portion of the bridge equipage necessary for the special instruction of this corps, as well as of the material of the artillery properly belonging to this instruction.

The lieutenant-colonel, assistant to the general, fulfills, independent of every other detail of supervision with which he may be charged, the functions of *ordonnateur secondaire*, in what concerns the expenses of the school and their propriety (*justification.*) He corresponds with the minister of war for this part of the service.

The instruction is divided into *theoretical* and *practical*, and the annual course is divided into half-yearly periods, or into summer and winter instructions.

The summer instruction commences, according to different localities, from the 1st of April to the 1st of May, and that of the winter from the 1st of October to the 1st of November.

The winter and summer instruction is subdivided into school and regimental instruction.

The school instruction comprehends all the *theoretical* and *practical* instruction common to the different corps which require the

assistance of the particular means of the school, the employment of its professors, locality, and material, as that of the practical instruction in which the troops belonging to the different corps of the army are united to take part.

The regimental instruction is that which exists in the interior of the regiments and the various bodies of the artillery. It is directed by the chiefs of these corps, who are responsible for it, with the means placed at their disposal, under the general surveillance of the commandant of the school.

The special instruction of the Pontooneers not admitting of their following the same instruction as the other regiments of artillery, the chief of this corps directs the special instruction according to certain bases prescribed by the regulations.

There are for the captains of artillery, each year during the winter half-year, six conferences for the purposes of considering and discussing projects for the organization of different equipages and armaments for the field service, and for attack and defense of places.

In a building belonging to each school of artillery, under the name of the hotel of the school, are united the halls and establishments necessary for the theoretical instruction of the officers and sous-officers, such as halls for *théorique* drill and drawing, library, depots of maps and plans, halls for machines, instruments and models, &c.

Each school is provided with a physical cabinet and a chemical laboratory. There is also a piece of ground, called a polygon, for exercising artillerymen to the manœuvers of cannon and other fire-arms of great range. Its extent is sufficient in length to furnish a range of 1,200 meters, and in breadth of 600 meters.

Permanent and temporary batteries are established on this ground, and they seem not only for practice, but also to accustom the men to the construction of fascines, field batteries, &c.

The administration of each school, and the accounts relating to it, are directed by an administrative council, consisting of—

The General Officer commanding the Artillery (President.)

The Colonels of the regiments of Artillery in the towns where two regiments of the Artillery are quartered, and in other towns, the Colonel and Lieutenant-Colonel of the regiment.

The Colonel of the regiment of Pontooneers in the town where the principal part of the corps may be stationed, and in any other town the Lieutenant-Colonel or the Major.

The Lieutenant-Colonel associated assistant with the General Commandant.

The functions of secretary of the council are intrusted to a *grade* of the first class.

The functionaries of the corps of intendants fulfill, in connection

with the administrative councils of the artillery schools, the same duties as are assigned by the regulations relating to the interior administration of bodies of troops. They will exercise over the accounts, both of money and material of the said schools, the same control as over the administration connected with the military interests of the state.

II. ENGINEER REGIMENTAL SCHOOLS.

The colonel of each regiment has the superior direction of the instruction.

The lieutenant-colonel directs and superintends, under his orders, the whole of the details of the regimental instruction.

A major, selected from among the officers of this rank belonging to the *état-major* of this arm, directs and superintends, under the orders of the colonel, the whole of the details of the special instruction.

The complete instruction consists of—

General instruction, or that of the regiment, by which a man is made a soldier.

Special or school instruction, having for its object the training of the miner or sapper.

The instructions are each separated into *theoretical* and *practical* instruction.

The theoretical instruction of the regiment comprehends the theories:—

On the exercises and manœuvers of infantry. On the interior service. On the service of the place. On field service. On the maintenance of arms. On military administration. On military penal legislation.

The practical instruction of the regiment comprises:—

The exercises and manœuvers of infantry. Practice with the musket. Military Marches. Fencing.

The teaching of these various duties is confided to officers, *sous-officiers*, and corporals of the regiments, as pointed out by the regulation, and the orders of the colonel.

The fencing school is organized in a similar manner to those of the infantry, and the military marches are also made in the same way as in those corps.

The *special* and *theoretical* instruction consists of:—

Primary instruction. Mathematics. Drawing. Geography. Military history of France. Fortification and the various branches of the engineering work.

Three civil professors (appointed by competition) are attached to each regimental school, for the special theoretical instruction, as regards the primary instruction, drawing, and mathematics.

The courses are distributed and taught in the following manner:

Primary instruction for the Soldiers. French grammar for the Corporals. Book-keeping for the *Sous-Officiers*. Elementary arithmetic for the Corporals.	By the Professor of Primary Instruction.
Complete arithmetic, Elementary geometry — for the Serjeants. Complete geometry, Trigonometry — for the Serjeant-Major. Surveys for the *Sous-Officiers*. Special mathematics for the Officers.	By the Prof. of Mathematics.
Drawing for the Corporals and *Sous-Officers*.	By the Professor of Drawing, who is also charged with completing the collection of models which relate to it.
The elements of fortification for the Serjeant-Majors. Construction, and theories on practical schools — for the *Sous-Officiers*. Permanent fortification The attack and defense of places Mines Bridges Ovens Topography — for the Officers. Geography Military history of France — for the *Sous-Officiers*.	By the Officers of the regiment, named by the Colonel, independently of those appointed by the regulations

At the end of each course the colonel of the regiment causes a general examination to be made in his presence of the whole of the men who have followed this course, and has a list made out in the order of merit, with notes of the capacity and aptitude of each.

These lists are consulted in the formation of tables of promotion, and placed with the said tables before the inspector-general.

Each captain and lieutenant are obliged to give in at least a single treatise on five different projects, consisting of a memoir discussing or the journal of a siege, with drawing of the whole, and of details in sufficient number to render them perfectly intelligible.

The *special practical* instruction is composed of seven distinct schools, relating to:—

Field Fortification. Saps. Mines and Fireworks. Bridges. Ovens. Topography. Gymnastics.

And they comprehend, in addition, sham sieges, and underground war. Each of these seven schools is taught in accordance with the special instructions annexed to the regulation, which, however, are not published.

Winter is more especially devoted to the course of special theoretical instruction, which commences on the 1st November, and usually finishes on the 15th March, and the course of *special practical* instruction is carried on during the summer from the 15th March to the 15th September. The second fortnight of September and the month of October are devoted to sham sieges and underground war, to the leveling of the works executed, and to the arrangement of magazines.

SCHOOL FOR INFANTRY AND CAVALRY

AT ST. CYR.

GENERAL DESCRIPTION. CONDITIONS OF ADMISSION. STAFF.

It will have been seen in the accounts of the Polytechnic School and the School of Application at Metz, in what manner young men destined for commissions in the artillery and engineers receive their previous education, and under what conditions appointments as officers in these two services are made in France. The regulations for the infantry, the cavalry, and the marines are of the same description. There are in these also the same two ways of obtaining a commission. One, and in these services the more usual one, is to rise from the ranks. The other is to pass successfully through the school at St. Cyr. Young men who do not enter as privates prove their fitness for the rank of officers by going through the course of instruction given, and by passing the examinations conducted in this, the principal, and putting aside the School of Application at Metz, the one Special Military School of the country.

The earliest foundation of the kind in France was the Ecole Royale Militaire of 1751. Like most other similar institutions of the time, it was intended for the young nobility. No one was to be admitted who could not prove four generations of *Noblesse*. The pupils were taught free of charge, and might enter at eight years old. Already, however, some marks of competition are to be discerned, as the best mathematicians were to be taken for the Artillery and Engineers. Buildings on the Plain of Grenelle (the same which still stand, occupying one end of the present Champs de Mars, and retaining, though only used as barracks, their ancient name,) were erected for the purpose. The school continued in this form till 1776, when it was dissolved (apparently owing to faults of discipline,) and replaced by ten Colleges, at Sorrèze, Brienne, Vendôme, and other places, all superintended by ecclesiastics. A new Ecole Royale Militaire, occupying the same buildings as the former, was added in 1777.

This came to an end in 1787; and the ten colleges were suppressed under the Republic. A sort of Camp School on the plain

of Sablons took their place, when the war had broken out, and lasted about a year under the name of the Ecole de Mars.

Under the Consulate in 1800, the Prytanée Français was founded, consisting of four separate Colleges. The name was not long after changed to the Prytanée Militaire; and after some time the number was diminished, and La Flèche, which had in 1764 received the youngest pupils of the old Royal Military School, became the seat of the sole remaining establishment; which subsequently sunk to the proportions of a mere junior preparatory school, and became, in fine, the present establishment for military orphans, which still retains the title, and is called the Prytanée Militaire de la Flèche.

A *special* Military School, in the meantime, had been set up at Fontainebleau in 1803, transferred in 1808 to St. Cyr, and thus taking the place of the Prytanée Militaire and of its predecessor, the original Ecole Royale Militaire, gradually assumed its present form.*

The course of study lasts two years; the usual number of cadets in time of peace is five, or at the utmost six hundred; the admission is by competitive examination, open to all youths, French by birth or by naturalization, who on the first of January preceding their candidature were not less than sixteen and not more than twenty years old. To this examination are also admitted soldiers in the ranks between twenty and twenty-five years of age, who, at the date of its commencement, have been actually in service in their regiments for two years.

The general conditions and formalities are the same as those already stated for the Polytechnic. It may be repeated that all the candidates, in accordance with a recent enactment, must have taken the usual degree which terminates the task at the *lycées*—the baccalaureate in sciences.

Those who succeed in the examination and are admitted, take an engagement to serve seven years either in the cavalry or infantry, and are thus under the obligation, if they are judged incompetent at the close of their two years' stay at the school to receive

* Founded the Ecole Royale Militaire, 1751. Junior pupils transferred to La Flèche, 1764.
Suppression of the Ecole Royale Militaire and establishment of ten Colleges, 1776.
New Ecole Royale Militaire, for the best pupils of the Colleges, 1777.
Suppression of the Colleges and of the Ecole Royale Militaire, 1787.
Foundation of the Ecole de Mars, May 1794.
Foundation of the Prytanée Français at Paris, Versailles, St. Germain, Fontainebleau, 1800.
Foundation of the Ecole Spéciale Militaire at Fountainebleau, 1803.
The four Schools of the Prytanée Français are converted into the Prytanée Militaire, 1806; and are transferred to La Flèche, 1808.
The Ecole Spéciale Militaire is transferred to St. Cyr, also in 1808.

a commission, to enter and serve as common soldiers. The two years of their stay at the school counts as a part of their service. It is only in the special case of loss of time caused by illness, that permission is given to remain a third year.

The ordinary payment is 60*l.* (1,500 francs) per annum. All whose inability to pay this amount is satisfactorily established, may claim, as at the Polytechnic, an allowance of the whole or of half of the expenses from the State, to which may be added an allowance for the whole or for a portion of the outfit (from 24*l.* to 28*l.*) These *bourses* or *demi-bourses*, with the *trousseau*, or *demi-trousseau*, have during the last few years been granted unsparingly. One-third of the 800 young men at the school in February 1856 were *boursiers* or *demi-boursiers*. Candidates admitted from the Orphan School of La Flèche, where the sons of officers wounded or killed in service receive a gratuitous education, are maintained in the same manner here.*

It was the rule till lately that cadets appointed, on leaving St. Cyr, to the cavalry should be placed for two years at the Cavalry School at Saumur. This, however, has recently been changed; on entering St. Cyr those who desire appointments in the cavalry declare their wishes, and are put at once through a course of training in horsemanship. Those who are found unfit are quickly withdrawn; the remainder, if their place on the final examination allows of their appointment to the cavalry, are by that time sufficiently well practiced to be able to join their regiments at once.

Twenty-seven, or sometimes a greater number, are annually at the close of their second year of study placed in competition with twenty-five candidates from the second lieutenants belonging to the army,† if so many are forthcoming, for admission to the Staff School at Paris. This advantage is one object which serves as a stimulus to exertion, the permission being given according to rank in the classification by order of merit.

The school consists of two divisions, the upper and the lower, corresponding to the two years of the course. Each division is divided again into four companies. In each of these eight companies there are sub-officers chosen from the *élèves* themselves, with

* About twenty-five are sent every year from La Flèche. The admissions from the army (*i. e.*, of soldiers between twenty and twenty-five years old) do not amount to more than four or at the utmost five per cent. They are very frequently young men who have previously failed for St. Cyr. and who then enter the army as privates, and come in as such. They have to pass the same examination.

† Few usually present themselves; and these also, it is said, are very generally old *élèves* of St. Cyr. who had not succeeded in obtaining admission to the Staff School before. They are not examined *with* the pupils of St. Cyr, but are intercalated in the list according to their merit.

the titles of *Sergent*, *Sergent Fourrier*, and *Caporal;* those appointed to the companies of the junior division are selected from the second year cadets, and their superiority in standing appears to give these latter some considerable authority, exercised occasionally well, occasionally ill. The whole school, thus divided into eight companies, constitutes one battalion.

The establishment for conducting the school consists of—

A General as Commandant.
A Second in Command (a Colonel of Infantry.)
A Major, 4 Captains, 12 Lieutenants, and 5 Second Lieutenants of Infantry; the Major holding the office of Commandant of the Battalion.
A Major, 1 Captain, 34 Lieutenants, and 3 Second Lieutenants of Cavalry to superintend the exercises, the riding, &c.
A Director of Studies (at present a Lieutenant-Colonel of Engineers.)
Two Assistant Directors.
Six Examiners for Admission.
One Professor of Artillery.
One Assistant ditto.
One Professor of Topography and Mathematics.
One Professor of Military Administration, Military Art, and Military History.
One Professor of Fortification.
One Professor of Military Literature.
Two Professors of History and Geography.
One Professor of Descriptive Geometry.
One Professor of Physics and Chemistry.
Three Professors of Drawing,
One Professor of German.
Eleven Military and six Civilian Assistant Teachers (*Répétiteurs.*)

There is also a Quartermaster, a Treasurer, a Steward, a Secretary of the Archives, who is also Librarian, an Almoner (a clergyman,) four or five Surgeons, a Veterinary Surgeon, who gives lessons on the subject, and twelve Fencing Masters.

The professors and teachers are almost entirely military men. Some difficulty appears to be found by civilians in keeping sufficient order in the large classes; and it has been found useful to have as *répétiteurs* persons who could also be employed in maintaining discipline in the house. Among the professors at present there are several officers of the engineers and of the artillery, and of the staff corps.

There is a board or council of instruction, composed of the commandant, the second in command, one of the field officers of the school staff, the director of studies, one of the assistant directors, and four professors.

So, again, the commandant, the second in command, one of the field officers, two captains, and two lieutenants, the last four changing every year, compose the board or council of discipline.

St. Cyr is a little village about three miles beyond the town of Versailles, and but a short distance from the boundary of the park. The buildings occupied by the school are those formerly used by Madame de Maintenon, and the school which she superintended.

Her garden has given place for the parade and exercise grounds; the chapel still remains in use; and her portrait is preserved in the apartments of the commandant. The buildings form several courts or quadrangles; the Court of Rivoli, occupied chiefly by the apartments and bureaux of the officers of the establishment, and terminated by the chapel; the Courts of Austerlitz, and Marengo, more particularly devoted to the young soldiers themselves; and that of Wagram, which is incomplete, and opens into the parade grounds. These, with the large stables, the new riding school, the exercising ground for the cavalry, and the polygon for artillery practice, extend to some little distance beyond the limit of the old gardens into the open arable land which descends northwards from the school, the small village of St. Cyr lying adjacent to it on the south.

The ground floor of the buildings forming the Courts of Marengo, Austerlitz, and Wagram appeared to be occupied by the two refectories, by the lecture-rooms or amphitheaters, each holding two hundred pupils, and by the chambers in which the ordinary questionings, similar to those already described in the account of the Polytechnic School, under the name of *interrogations particulières*, are conducted.

On the first floor are the *salles d'étude* and the *salle des collections* the museum or repertory of plans, instruments, models and machines, and the library; on the second floor the ordinary dormitories; and on the third (the attics,) supplementary dormitories to accommodate the extra number of pupils who have been admitted since the commencement of the war.

The commission, when visiting the school, was conducted on leaving the apartments of the commandant to the nearest of the two refectories. It was after one o'clock, and the long room was in the full possession of the whole first or junior division. A crowd of active and spirited-looking young soldiers, four hundred at least in number, were ranged at two long rows of small tables, each large enough, perhaps, for twelve; while in the narrow passage extending up and down the room, between the two rows, stood the officers on duty for the maintenance of order. On passing back to the corridor, the stream of the second year cadets was issuing from their opposite refectory. In the adjoining buttery, the loaf was produced, one kilogramme in weight, which constitutes the daily allowance. It is divided into four parts, eaten at breakfast, dinner, the afternoon lunch or *gouter*, and the supper. The daily cost of each pupil's food is estimated at 1 f. 80 c.

The lecture rooms and museums offer nothing for special remark. In the library containing 12,000 books and a fine collection of maps, there were a few of the young men, who are admitted during one hour every day.

The *salles d'étude* on the first floor are, in contrast to those at the Polytechnic, large rooms, containing, under the present circumstances of the school, no less than two hundred young men. There are, in all, four such rooms, furnished with rows of desks on each side and overlooked in time of study by an officer posted in each to preserve order, and, so far as possible, prevent any idleness.

From these another staircase conducts to the dormitories, containing one hundred each, and named after the battles of the present war—Alma, Inkerman, Balaclava, Bomarsund. They were much in the style of those in ordinary barracks, occupied by rows of small iron beds, each with a shelf over it, and a box at the side. The young men make their own beds, clean their own boots, and sweep out the dormitories themselves. Their clothing, some portions of which we here had the opportunity of noticing, is that of the common soldier, the cloth being merely a little finer.

Above these ordinary dormitories are the attics, now applied to the use of the additional three hundred whom the school has latterly received.

The young men, who had been seen hurrying with their muskets to the parade ground, were now visible from the upper windows, assembled, and commencing their exercises. And when, after passing downwards and visiting the stables, which contain three hundred and sixty horses, attended to by two hundred cavalry soldiers, we found ourselves on the exercising ground, the cavalry cadets were at drill, part mounted, the others going through the lance exercise on foot. In the riding-school a squad of infantry cadets were receiving their weekly riding lesson. The cavalry cadets ride three hours a-day; those of the infantry about one hour a week. The exercising ground communicates with the parade ground; here the greater number of the young men were at infantry drill, under arms. A small squad was at field-gun drill in an adjoining square. Beyond this and the exercising ground is the practice ground, where musket and artillery practice is carried on during the summer. Returning to the parade ground we found the cadets united into a battalion; they formed line and went through the manual exercise, and afterwards marched past; they did their exercise remarkably well. Some had been only three months at the school. The

marching past was satisfactory; it was in three ranks, in the usual French manner.

Young men intended for the cavalry are instructed in infantry and artillery movements and drill; just as those intended for the infantry are taught riding, and receive instruction in cavalry, as well as artillery drill and movements.

It is during the second year of their stay they receive most instruction in the arms of the service to which they are not destined, and this, it is said, is a most important part of their instruction. "It is this," said the General Commandant, "that made it practicable, for example, in the Crimea, to find among the old *élèves* of St. Cyr, officers fit for the artillery, the engineers, the staff; and for general officers, of course, it is of the greatest advantage to have known from actual study something of every branch."

The ordinary school vacation last six or seven weeks in the year. The young men are not allowed to quit the grounds except on Sundays. On that day there is mass for the young men.

The routine of the day varies considerably with the season. In winter it is much as follows:—At 5 A. M. the drum beats, the young men quit theis beds; in twelve minutes they are all dressed and out, and the dormitories are cleared. The *rappel* sounds on the *grand carré;* they form in their companies, enter their *salles*, and prepare for the lecture of the day until a quarter to 7. At 7 o'clock the officers on duty for the week enter the dormitories, to which the pupils now return, at a quarter to 8 the whole body passes muster in the dormitories, in which they have apparently by this time made their beds and restored cleanliness and order. Breakfast is taken at one time or other during the interval between a quarter to 7 and 8 o'clock.

They march to their lecture rooms at 8, the lecture lasts till a quarter past 9, when they are in like manner marched out, and are allowed a quarter of an hour of amusement. They then enter the halls of study, make up their notes on the lecture they have come from, and after an hour and a half employed in this way, for another hour and a half are set to drawing.

Dinner at 1 is followed by recreation till 2. Two hours from 2 to a quarter past 4 are devoted to military services.

From 4 to 6 P. M. part are occupied in study of the drill-book (*théorie,*) part in riding or fencing: a quarter of an hour's recreation follows, and from 6½ to 8½ there are two hours of study in the *salles*. At half-past 8 the day concludes with the supper.

The following table gives a view of the routine in summer :—

4½	A. M.	to	4¾	A. M.	Dressing.
4¾	"	to	7½	"	Military exercises.
7½	"	to	8½	"	Breakfast, cleaning, inspection.
8½	"	to	9½	"	Lecture.
9½	"	to	9¾	"	Recreation.
9¾	"	to	11½	"	Study.
11½	"	to	1	P. M.	Drawing.
1	P. M.	to	2	"	Dinner and recreation.
2	"	to	4	"	Study of drill-book (*théorie*) or fencing.
4	"	to	6	"	Study for some, riding for others.
6	"	to	6½	"	Recreation.
6½	"	to	8	"	Riding for some, study for others,
8	"	to	8½	"	Supper.

The entrance examination is much less severe than that for the Polytechnic; but a moderate amount of mathematical knowledge is demanded, and is obtained. The candidates are numerous; and if it be true that some young men of fortune shrink from a test, which, even in the easiest times, exacts a knowledge of the elements of trigonometry, and not unfrequently seek their commissions by entering the ranks, their place is supplied by youths who have their fortunes to make, and who have intelligence, industry, and opportunity enough to acquire in the ordinary *lycées*, the needful amount of knowledge.

Under present circumstances it is, perhaps, more especially in the preparatory studies that the intellectual training is given, and for the examination of admission that theoretical attainments are demanded. The state of the school in a time of war can not exactly be regarded as a normal or usual one. The time of stay has been sometimes shortened from two years to fifteen months; the excessive numbers render it difficult to adjust the lectures and general instruction so as to meet the needs of all; the lecture rooms and the studying rooms are all insufficient for the emergency; and what is yet more than all, the stimulus for exertion, which is given by the fear of being excluded upon the final examination, and sent to serve in the ranks, is removed at a time when almost every one may feel sure that a commission which must be filled up will be vacant for him. Yet even in time of peace, if general report may be trusted, it is more the drill, exercises, and discipline, than the theory of military operations, that excite the interest and command the attention of the young men. When they leave, they will take their places as second lieutenants with the troops, and they naturally do not wish to be put to shame by showing ignorance of the common things with which common soldiers are familiar. Their chief incentive is the fear of being found deficient when they join their reg-

iments, and, with the exception of those who desire to enter the staff corps, their great object is the practical knowledge of the ordinary matters of military duty. "Physical exercises," said the Director of Studies, "predominate here as much as intellectual studies do at the Polytechnic."

But the competition for entrance sustains the general standard of knowledge. Even when there is the greatest demand for admissible candidates, the standard of admission has not, we are told, been much reduced. No one comes in who does not know the first elements of trigonometry. And the time allotted by the rules of the school to lectures and indoor study is far from inconsiderable.

EXAMINATIONS FOR ADMISSION—STUDIES AT THE SCHOOL.

The examinations for admission are conducted almost precisely upon the same system which is now used in those for the Polytechnic School.* There is a preliminary or pass examination (*du premier degré,*) and for those who pass this a second or class examination (*du second degré.*) For the former there are three examiners, two for mathematics, physics, and chemistry, and a third for history, geography, and German. The second examination, which follows a few days after, is conducted in like manner by three examiners. A jury of admission decides. The examination is for the most part oral; and the principal difference between it and the examination for the Polytechnic is merely that the written papers are worked some considerable time before the first oral examination (*du premier degré,*) and are looked over with a view to assist the decision as to admissibility to the second (*du second degré.*) Thus the *compositions écrites* are completed on the 14th and 15th of June; the preliminary examination commences at Paris on the 10th of July; the second examination on the 13th.

The subjects of examination are the following:—

Arithmetic, including vulgar and decimal fractions, weights and measures, square and cube root, ratios and proportions, interest and discount, use of logarithmic tables and the sliding rule.

Algebra, to quadratic equations with one unknown quantity, maxima and minima, arithmetical and geometrical progressions, logarithms and their application to questions of compound interest and annuities.

Geometry, plane and solid, including the measurement of areas, surfaces, and volumes; sections of the cone, cylinder, and sphere.

Plane Trigonometry: construction of trigonometrical tables and the solution of triangles; application to problems required in surveying.

Geometrical representations of bodies by projections.

* The system was, in fact, first tried at St. Cyr, and adopted, on the representation of the Mixed Commission, at the Polytechnic. The previous method, by which different sets of examiners took different districts, had created distrust and dissatisfaction.

French compositions.
German exercises.
Drawing, including elementary geometrical drawing and projections; plan, section, and elevation of a building; geographical maps.
Physical Science (purely descriptive:) cosmography; physics, including elementary knowledge of the equilibrium of fluids; weight, gravity, atmospheric pressure, heat, electricity, magnetism, acoustics, optics, refraction, microscope, telescope.
Chemistry, elementary principles of; on matter, cohesion, affinity; simple and compound bodies, acids, bases, salts, oxygen, combustion, azote, atmospheric air, hydrogen, water; respecting equivalents and their use, carbon, carbonic acid, production and decomposition of ammonia, sulphur, sulphuric acid, phosphorus, chlorine; classification of non-metallic bodies into four families.
History: History of France from the time of Charles VII. to that of the Emperor Napoleon I. and the treaties of 1815.
Geography, relating entirely to France and its colonies, both physical and statistical.
German: the candidates must be able to read fluently both the written and printed German character, and to reply in German to simple questions addressed to them in the same language.

The general system of instruction at St. Cyr is similar to that of the Polytechnic; the lectures are given by the professors, notes are taken and completed afterwards, and progress is tested in occasional *interrogations* by the *répétiteurs*. One distinction is the different size of the *salles d'étude* (containing two hundred instead of eight or ten;) but, above all, is the great and predominant attention paid to the practical part of military teaching and training. It is evident at the first sight that this is essentially a military school, and that especial importance is attached both by teachers and pupils to the drill, exercise, and manœuvers of the various arms of the service.

The course of study is completed in two years; that of the first year consists of:—

27	lectures	in descriptive geometry.
35	"	physical science.
20	"	military literature.
35	"	history.
27	"	geography and military statistics.
30	"	German.
Total, 174		

In addition to the above, there is a course of drawing between the time when the students join the school early in November and the 15th of August.

The course of *drawing* consists in progressive studies of landscape drawing with the pencil and brush, having special application to military subjects, to the shading of some simple body or dress, and to enable the students to apply the knowledge which has been communicated to them on the subject of shadows and perspective. This course is followed by the second or junior division during the first year's residence.

The course of lectures in *descriptive geometry* commences with certain pre-

liminary notions on the subject; refers to the representation of lines on curved surfaces, cylindrical and conical, surfaces of revolutions, regular surfaces, intersection of surfaces, shadows, perspective, vanishing points, &c., construction of geographical maps, and *plan côté*.

The lectures in *physical science* embrace nine lectures on the general properties of bodies; heat, climate, electricity, magnetism, galvanism, electro-magnetism, acoustics.

There are twelve lectures in *chemistry;* on water, atmospheric air, combustibles, gas, principal salts, saltpetre, metallurgy, organic chemistry.

There are fourteen lectures in *mechanics applied to machines;* motion, rest, gravity, composition and resolution of forces, mechanical labor, uniform motion, rectilinear and rotatory, projectiles in space, mechanical powers, drawbridges, Archimedean principle, military bridges, pumps, reservoirs, over and under-shot wheels, turbines, corn mills, steam-engines, locomotives, transport of troops, materials, and munitions on railways.

The twenty lectures in *military literature* refer to military history and biography, memoirs of military historians, battles and sieges, the art of war, military correspondence, proclamations, bulletins, orders of the day, instructions, circulars, reports and military considerations, special memoirs, reconnaissance and reports, military and periodical collections, military justice.

The thirty-five lectures in *history* principally relate to France and its wars, commencing with the Treaty of Westphalia and ending with the Treaty of Vienna.

The twenty-seven lectures in *geography* and *military statistics* are subdivided into different parts; the first eight lectures are devoted to Europe and France, including the physical geography and statistics of the same; the second six lectures are devoted to the frontiers of France; and the third part of thirteen lectures to foreign states and Algeria, including Germany, Italy, Spain, Portugal, Poland, and Russia.

The studies for the first division during the second year of their residence consist of—

10	lectures in	topography.
27	"	fortification.
15	"	artillery.
10	"	military legislation.
12	"	military administration.
27	"	military art and history.
20	"	German.
Total, 121		

One lesson weekly is given in drawing, in order to render the students expert in landscape and military drawing with the pencil, pen, and brush.

We must not omit to call attention to the fact that mathematics are not taught in either yearly course at St. Cyr.

The course in *topography*, of ten lectures, has reference to the construction of maps, copies of drawings, theory, description, and use of instruments for measuring angles and leveling, the execution for a regular survey on the different systems of military drawing, drawing from models of ground, on the construction of topographical drawing and reconnaissance surveys, with accompanying memoirs.

Twenty-seven lectures are devoted to *fortification;* the first thirteen relate principally to field fortification, statement of the general principles, definitions, intrenchments, lines, redoubts, armament, defilement, execution of works on the ground, means necessary for the defense, application of field fortification to the defenses of *têtes de pont* and inhabited places, attack and defense of in-

trenchments, &c., castramentation; six lectures have reference to permanent fortification, on ancient fortifications, Cormontaigne's system, exterior and detached works, considerations respecting the accessories of defense to fortified places; eight lectures relate to the attack and defense of places, preparations for attack and defense, details of the construction of siege works from the opening of the trenches to the taking of the place, exterior works, as auxiliaries, sketches, and details of the different works in fortifications, plans, and profile, &c.

The students also execute certain works, such as the making of fascines, gabions, saucissons, repair of revetments of batteries, platform, setting the profiles, defilement, and construction of a fieldwork, different kinds of sap, plan and establishment of a camp for a battalion of infantry, &c.

Under the head of *artillery*, fifteen lectures are given, commencing with the resistance of fluids, movement of projectiles, solution of problems with the ballistic pendulum, deviation of projectiles, pointing and firing guns; small arms, cannon, materials of artillery, powder, munition, fireworks for military purposes; range of cannon, artillery for the attack or defense of places or coasts, field artillery, military bridges.

The students are practically taught artillery drill with field and siege guns, practice with artillery, repair of siege batteries, bridges of boats or rafts.

The ten lectures allowed for the course of *military legislation* have for their object the explanation of the principles, practice, and regulations relating to military law, and the connection with the civil laws that affect military men.

The twelve lectures on what is called *military administration* relate to the interior economy of a company, and to the various matters appertaining to the soldier's messing, mode of payment, necessaries, equipment, lodging, &c.

Military art and history is divided into three parts. The first, of five lectures, relates to the history of military institutions and organization. The second, of fifteen lectures, refers to the composition of armies and to considerations respecting the various arms, infantry, cavalry, état-major, artillery and engineers, and the minor operations of war. The third part, of seven lectures, gives the history of some of the most celebrated campaigns in modern times. In the practical exercises, the students make an attack or defense of a work or of a system of fieldworks during their course of fortification, or of a house, farm, village, in the immediate vicinity of the school, or make the passage of a river.

The students receive twenty lectures in *German*, and are required to keep up a knowledge of German writing.

EXAMINATIONS AT THE SCHOOL.

The examinations at the end of the first year take place under the superintendence of the director and assistant director of studies. They are conducted by the professor of each branch of study, assisted by a *répétiteur*, each of whom assigns a credit to the student under examination, and the mean, expressed as a whole number, represents the result of the student's examination in that particular branch of study. The examination in military instruction for training (in drill and exercises) is carried on by the officers attached to companies, under the superintendence of the commandant of the battalion, and that relating to practical artillery by the officer in charge of that duty.

The pupils' position is determined, as at the Polytechnic, partly by the marks gained at the examination, partly by those he has obtained during his previous studies. In other words, the half of the credit obtained by a student at this examination in each subject is added to the half of the mean of all the credits assigned to him,

in the same subject, for the manner in which he has replied to the questions of the professor and *répétiteur* during the year; and the sum of these two items represents his total credit at the end of the year. The scale of credit is from 0 to 20, as at the Polytechnic.

Every year, before the examinations commence, the commandant and second in command, in concert with the director and assistant director, and in concurrence with the superior officer commanding the battalion for military instruction, are formed into a board to determine the amount of the minimum credit which should be exacted from the students in every branch of study. This minimum is not usually allowed to fall below eight for the scientific, and ten for the military instruction.

Any student whose general mean credit is less than *eight* for the scientific, or *ten* for the military instruction, or who has a less credit than *four* for any particular study in the general instruction, or of *six* for the military instruction, is retained at the school to work during the vacation, and re-examined about eight days before the re-commencement of the course, by a commission composed of the director and assistant director of studies for the general instruction, and of the second in command and the commandant of the battalion, and of one captain for the military instruction. A statement of this second examination is submitted to the minister of war, and those students who pass it in a satisfactory manner are permitted by him to proceed into the first division. Those who do not pass it are reported to the minister of war as deserving of being excluded from the school, unless there be any special grounds for excusing them, such as sickness, in which case, when the fact is properly established before the council of instruction, they are permitted to repeat the year's studies.

Irregularity of conduct is also made a ground for exclusion from the school. In order to estimate the credit to be attached to the conduct of a student, all the punishments to which he can be subjected are converted into a specific number of days of punishment drill. Thus,

For each day confined in the police chamber, 4 days' punishment drill.

For each day confined in the prison, 8 days' punishment drill.

The statement is made out under the presidency of the commandant of the school, by the second in command, and the officer in command of the battalion. The credits for conduct are expressed in whole numbers in terms of the scale of 0 to 20, in which the 20 signifies that the student has not been subjected to any punishment

whatever, and the 0, that the student's punishments have amounted to 200 or more days of punishment drill. The number 20 is diminished by deducting 1 for every 10 days of punishment drill.

The classification in the order of merit depends upon the total amount of the sum of the numerical marks or credits obtained by each student in every branch of study or instruction. The numerical credit in each subject is found by multiplying the credit awarded in each subject by the co-efficient of influence belonging to it.

The co-efficients, representing the influence allowed to each particular kind of examination, in the various branches of study are as follows:—

Second Division, or First Year's Course of Study.

General Instruction.	Descriptive Geometry,	Course,	6	40
		Drawing and Sketches,	2	
	Physical Science applied to the Military Arts,	Course,	6	
		Sketch and Memoir,	2	
	History,		6	
	Geography and Statistical Memoirs,	Course,	5	
		Sketch and Memoir,	2	
	Literature, Memoir on		4	
	German,		4	
	Drawing,		3	
Special Instruction:—Drill, Practice, Manœuvers (Infantry and Cavalry,)				7
Conduct,				3
				50

First Division, or Second Year's Course of Study

			Infantry.	Cavalry.	
General Instruction.	Topography,	Course,	3	3	32
		Maps, Memoirs, and Practical Exercises,	3	2	
	Fortification,	Course,	4	4	
		Drawings, Memoirs, and Practical Exercises,	3	2	
	Artillery and Balistic Pendulum,	Course,	4	4	
		Practical Exercises, School of Musketry,	2	1	
	Military Legislation,		2	2	
	Military Administration,	Course,	3	3	
		Sheets of Accounts,	1	1	
	Military History and Art,	Course,	4	4	
		Memoirs and applications,	1	1	
	German,		4	4	
	Drawing,		1	1	
Special instruction for	Infantry,	Theory of Drill, Manœuvers—3 Schools,	4		9
		Practical Instruction,	3		
		Regulations,	2		
	Cavalry,	Riding,		3	12
		Theoretical and Practical Instruction,		7	
		Veterinary Art,		2	
	Conduct			6	6
		Total,		50	50

To facilitate this classification in order of merit, three distinct tables are prepared,—

The first relating to the general instruction;

The second relating to the military instruction; and

The third relating to the conduct;

and they respectively contain, one column in which the names of the students are arranged by companies in the order in which they have been examined; followed by as many columns as there are subjects of examination, for the insertion of their individual credit and the co-efficient of influence, by which each credit is multiplied; and lastly by a column containing the sum of the various products belonging to, and placed opposite each student's name.

These tables are respectively completed by the aid of the existing documents, the first for the general instruction, by the director of studies; the second for the military instruction, by the officer commanding the battalion; the third for conduct, under the direction of the commandant of the school, assisted by the second in command.

A jury formed within the school, composed of the general commandant, president, the second in command, the director of studies, and the officer commanding the battalion, is charged with the classification of the students in the order of merit.

To effect it, after having verified and established the accuracy of the above tables, the numbers appertaining to each student in the three tables are extracted and inserted in another table, containing the name of each student, and, in three separate columns, the numbers obtained by each in general instruction, military instruction, and conduct, and the sum of these credits in another column.

By the aid of this last table, the jury cause another to be compiled, in which the students are arranged in the order of merit as established by the numerical amount of their credits, the highest in the list having the greatest number.

If there should be any two or more having the same number of total credits, the priority is determined by giving it to the student who has obtained a superiority of credits in military instruction, conduct, general instruction, notes for the year; and if these prove insufficient, they are finally classed in the same order as they were admitted into the school.

A list for passing from the second to the first division is forwarded to the minister at war, with a report in which the results for the year are compared with the results of the preceding year; and the minister at war, with these reports before him, decides who

are ineligible from incompetency, or by reason of their conduct, to pass to the other division.

The period when the final examinations before leaving the school are to commence, is fixed by the president of the jury, specially appointed to carry on this final examination, in concert with the general commandant of the school.

The president of the jury directs and superintends the whole of the arrangements for conducting the examination; and during each kind of examination, a member of the corps, upon the science of which the student is being questioned, assists the examiner, and, as regards the military instruction, each examiner is aided by a captain belonging to the battalion.

The examination is carried on in precisely the same manner as that already described for the end of the first year's course of study. And the final classification is ascertained by adding to the *numerical* credits obtained by each student during his second year's course of study, in the manner already fully explained, *one-tenth* of the numerical credits obtained at the examinations at the end of the first year.

The same regulations as to the minimum credit which a student must obtain in order to pass from one division to the other, at the end of the first year, which are stated in page 160, are equally applicable to his passing from the school to become a second lieutenant in the army.

A list of the names of those students who are found qualified for the rank of second lieutenant is sent to the minister at war, and a second list is also sent, containing the names of those students that have, when subjected to a second or revised examination, been pronounced by the jury before whom they were re-examined as qualified.

Those whose names appear in the first list are permitted to choose according to their position in the order of merit, the staff corps or infantry, according to the number required for the first named service, and to name the regiments of infantry in which they desire to serve.

Those intended for the cavalry are placed at the disposal of the officer commanding the regiment which they wish to enter.

Those whose names appear in the second list are not permitted to choose their corps, but are placed by the minister at war in such corps as may have vacancies in it, or where he may think proper.

The students who are selected to enter the staff corps, after competing successfully with the second lieutenants of the army, proceed as second lieutenants to the staff school at Paris. Those who fail pass into the army as privates, according to the terms of the engagement made on entering the school.

THE CAVALRY SCHOOL AT SAUMUR.

This school was established in 1826, and is considered* the most perfect and extensive institution of the kind in Europe,—perhaps the only one really deserving the title, the others being more properly mere schools of equitation.

It is under the control of the Minister of War, and was established for the purpose of perfecting the officers of the cavalry corps in all the branches of knowledge necessary to their efficiency, and especially in the principles of equitation,—and to diffuse through the corps a uniform system of instruction, by training up a body of instructors and classes of recruits intended for the cavalry service.

The instruction is entirely military, and is based upon the laws and regulations in force with regard to the mounted troops. It includes; 1st. The regulations for interior service; 2nd. The cavalry tactics; 3rd. The regulations for garrison service; 4th. The regulations for field service applied, as far as possible, on the ground, especially with regard to reconnaissances; 5th. A military and didactic course of equitation, comprising all the theoretical and practical knowledge required for the proper and useful employment of the horse, his breaking, application to the purposes of war, and various civil exercises; 6th. A course of hippology, having for its object practical instruction, by means of the model breeding-stud attached to the school, in the principles which should serve as rules in crossing breeds and in raising colts, to explain the phases of dentition, to point out the conformation of the colt which indicates that he will become a good and solid horse, the method to be pursued to bring the colt under subjection without resistance, and, finally, to familiarize the officers and pupils with all the knowledge indispensable to an officer charged with the purchase and care of remount horses. This course includes also a knowledge of horse-equipment, illustrated in the saddle factory connected with the school; 7th. Vaulting, fencing, and swimming. The non-commissioned officers are also instructed in the theory of administration and accountability. The course

* "Report of Observations in Europe during the Crimean War," by Major Gen. McClellan.

of instruction continues one year, commencing in the month of October. The pupils at the school are:—

1st. A division of lieutenants, (*lieutenants instructeurs.*)
2nd. " of sub-lieutenants, (*sous-lieutenants d'instruction.*)
3rd. " of sub-officers, (*sous-officiers élèves instructeurs.*)
4th. " of non-commissioned officers, (*brigadiers élèves.*)
5th. " of cavalry recruits, (*cavaliers élèves.*)

The lieutenants are chosen out of the regiments of cavalry and artillery, as well as from the squadrons of the park-trains and military equipages, from the lieutenants who voluntarily present themselves for the appointment to the General Board of Inspectors. Their age must not exceed thirty-six years.

The sub-lieutenants are appointed from the cavalry regiments, must be graduates of the Special Military School, not above thirty-four years of age, and have served at least one year with the regiment.

The sub-officers are selected from the cavalry corps—one from every two regiments of cavalry and artillery, and every two squadrons of the park-trains and military equipages.

The non-commissioned officers are chosen annually by the inspectors-general—one from each regiment of cavalry—from among those that show a peculiar aptness for equitation and are distinguished by good conduct, information, zeal, and intelligence; those who are recommended for promotion in their corps are selected in preference. Their age must not exceed twenty-five years, and they must have served at least one year in the ranks.

These pupils, numbering about four hundred, are sent to the school by order of the Minister of War. They continue connected with their corps, from which they are regarded as detached while they remain at the school. They receive additional pay. Those who after due trial are found deficient in the necessary qualifications, are sent back to their regiments.

Upon the recommendation of the inspector-general of the school, the officers who are serving as pupils, compete for promotion by choice with the officers of the corps from which they are detached.

The cavalry lieutenant, who graduates first in his class, is presented for the first vacancy as captain-instructor that occurs in the cavalry, provided he has the seniority of rank required by law. The lieutenant who graduates second obtains, under the same condition, the second vacancy of captain-instructor, provided his division consisted of more than thirty members. The sub-lieutenant graduating first, provided he is not lower than the tenth in the general classifi-

cation of the officers of both grades, is presented for promotion to the first vacant lieutenancy that occurs in his regiment.

The non-commissioned officers who pass a satisfactory final examination, are immediately promoted to vacancies that have been preserved for them in their regiments—those who have graduated among the first ten of the class, being presented for promotion as sub-lieutenants, as soon as they have completed their required term of service as non-commissioned officers. Those who attend the school as non-commissioned officers, frequently return as officers for instruction, and again in a higher grade on the staff of the school.

Officers transferred from the infantry to the cavalry are generally sent to this school for a short time at least. The captains-instructor of the cavalry regiments, and the instructors of equitation in the artillery regiments, are mostly selected from the graduates.

The school also receives by voluntary enlistment, such young men, not above the age of twenty-one years, as desire to enter the cavalry service. They are not admitted until they have been subjected to an examination before a committee, by whom they are classified according to their fitness. These volunteer enlistments for the cavalry school are made at Saumur, at least a month before the commencement of the course, on presentation of the certificate of classification and of approval by the commandant of the school. The number is limited to fifty each year.

Such of these cavalry pupils as are distinguished for diligence and good conduct and pass a satisfactory final examination are transferred to the regiments of cavalry, for promotion to the rank of non-commissioned officers by their respective colonels. Those who have not been found fit for admission are sent back simply as privates.

A council of instruction is charged with the direction of the studies. They propose useful changes, and direct the progress of the studies. They are also charged with the examinations.

The recitations are by sections of about thirty each. In reciting upon the general principles of tactics, equitation, hippology, &c., the manner is as in our Military Academy; when reciting upon the movements in tactics, all the commands and explanations of the instructor to the troops are repeated "verbatim et literatim," and in the tone and pitch of voice used in the field. Perfect uniformity of tone and manner is required. The object of thus reciting is to teach the pupils the proper tone and pitch of voice, to accustom them to hear their own voices, and to enable them to repeat the text literally at this pitch of voice, without hesitation or mistake.

The course of hippology includes the structure of the horse, the circulation of the blood, organs of respiration, &c., food, working

powers, actions, breeds, manner of taking care of him, ordinary ailments and remedies, shoeing, lameness, saddling, sore backs, sanitary police, &c., but does not comprise a complete veterinary course.

The practical exercises consist of:—the ordinary riding-hall drill, including vaulting, the "kickers," &c.; the carrière, or out-door riding at speed, over hurdles, ditches, &c.; cutting at head; target-practice; fencing; swimming; the usual military drills; skeleton squadron and regimental drills; rides in the country; finally, in the summer, frequent "carousels" or tilts are held.

The veterinary surgeons of the lowest grade are sent here upon their first appointment to receive instruction in equitation, to profit by the study of the model stud, and to learn the routine of their duties with the regiments. They form a distinct class.

In the *Model Stud*, the number of animals varies. There are usually two stallions and about twenty mares, (Arabs, English, Norman, &c.,) in addition to those selected from time to time from among the riding-animals. Attached to it is a botanical garden, more especially for useful and noxious grasses and plants.

School for Breaking Young Horses.—The best horses purchased at the remount dépôts are selected for the officers, and sent to this place to be trained. The number is fixed at 100 as a minimum. These, as soon as their education is complete, are sold or given, according to the orders of the Minister of War, to those officers who need a remount—in preference, to officers of the general staff and staff corps, those of the artillery, and mounted officers of infantry. These officers may also select from among the other horses of the school, with the approval of the commandant.

School of Farriers.—This is attached to the cavalry school, and is under the direction of the commandant. It is composed of private soldiers who have served at least six months with their regiments, and are blacksmiths or horse-shoers by trade. There are usually two men from each mounted regiment. The course lasts two years; it comprises reading, writing, arithmetic, equitation, the anatomy of the horse, thorough instruction as to all diseases, injuries, and deformities of the foot, something of the veterinary art in general, the selection of metals, making shoes, nails, tools, &c., shoeing horses. The establishment has a large shoeing shop and yard, a recitation-room, museum, and store-rooms. In the recitation-room there are skeletons of horses, men, &c., as well as some admirable specimens of natural preparations in comparative anatomy, a complete collection of shoeing-tools, specimens of many kinds of shoes, &c.—*Annuaire de l'Instruction* 1861, *and* "*Observations.*"

THE SCHOOL OF APPLICATION FOR THE STAFF.

AT PARIS.

DUTIES OF THE FRENCH STAFF.

The staff is the center from which issue and to which are addressed all orders and military correspondence.

The officers of the staff are divided into chiefs of the staff, sub-chiefs, staff-officers, and aides-de-camp.

The colonels and lieutenant-colonels are employed as chiefs of the staff in the different military districts of France, and in the divisions of the army on active service. The ordinary posts of the majors and captains is that of aides-de-camp to general officers.

When several armies are united together under a commander-in-chief, the chief of the general staff takes temporarily the title of *Major-Général*, the general officers employed under him that of *Aide-Major-Général*.

The duties of the chief of the staff are to transmit the orders of the general; to execute those which he receives from him personally, for field-works, pitching camps, reconnaissances, visits of posts, &c.; to correspond with the commanding officers of the artillery and the engineers, and with the commissariat, in order to keep the general exactly informed of the state of the different branches of the service; to be constantly in communication with the different corps, so as to be perfectly master of everything relating to them; to prepare for the commander-in-chief and for the minister of war, returns of the strength and position of the different corps and detachments, reports on marches and operations, and, in short, every necessary information.

The distribution of the other officers of different ranks, when it has not been made by the minister of war, is regulated by the chief of the general staff.

In every division of the army an officer of the staff is specially charged with the office work; the others assist him when necessary, but they are more usually employed in general staff duties, in reconnaissances, drawing plans of ground, missions, the arrangement of

camps and cantonments, superintending the distribution of the rations, &c.

The officers of the staff may further be charged with the direction of field-works thrown up to cover camps and cantonments.

Staff officers of all ranks may be employed on posts and detachments. On special missions they command all other officers of the same rank employed with them. When a staff officer is charged with the direction of an expedition or a reconnaissance, without having the command of the troops, the officer in command concerts with him in all the dispositions it may be necessary to make to ensure the success of the operation.

The staff of generals of artillery and of engineers is composed of officers of their respective arms.

The war depot (*Dépôt de la Guerre*) was founded for the purpose of collecting and preserving military historical papers, reconnaissances, memoirs, and plans of battles; to preserve plans and MSS. maps useful for military purposes, and to have them copied and published.

It is divided into two sections—one charged with trigonometrical surveying, topography, plan drawing, and engraving; the other with historical composition, military statistics, the care of the library, the archives, plans, and maps. Each of these sections is under the direction of a colonel of the staff corps, who has under his orders several officers of his corps.

The war depot has taken a large share in the preparation of the map of France. The first idea of undertaking this important work dates from 1808. After various delays and difficulties, the trigonometrical survey, which had been for a time suspended, was recommenced in 1818. The work was placed under the war depot, intrusted to the corps of geographical engineers. Since this period the geographical engineers have been incorporated in the staff corps, by the officers of which the work has been continued. The primary triangulation was finished in 1845; the secondary is now finished; the filling in the details will occupy several years to come. The number of officers of the staff corps employed on the survey has varied from twenty-six to ninety.

THE STAFF CORPS.

The officers of the French staff constitute a distinct and separate corps, numbering thirty-five colonels, thirty-five lieutenant-colonels, one hundred and ten majors, three hundred and thirty captains, and one hundred lieutenants. None but officers of this corps can be

employed on the staff. When, by accident, there is not a sufficient number present, regimental officers may be temporarily employed, but they return to their regiments as soon as officers of the staff corps arrive to replace them. The division of the staff into adjutant-general's and quartermaster-general's department does not exist in the French service.

The only means of entering the staff corps is through the Staff School of Application. Of the fifty student-officers which the School of Application usually contains, twenty-five leave annually to enter the staff corps, and are replaced by an equal number. Three of these come from the Polytechnic, the remaining twenty-two are selected from thirty pupils of the Military School of St. Cyr, who compete with thirty second lieutenants of the army, if so many present themselves; but, in general, the number of the latter does not exceed four or five.

The course of study in the Staff School of Application lasts two years. The students have the rank of second lieutenant. On passing the final examination they are promoted to the rank of lieutenant; they are then sent to the infantry to do duty for *two years*, at the expiration of which time they are attached for an equal period to the cavalry. They may finally be sent for a year to the artillery or engineers.

This routine can not be interrupted except in time of war, and even then the lieutenant can not be employed on staff duty until he has completed his *two years* with the infantry. However, officers who have a special aptitude for the science of geodesy or topography, may even earlier be employed on the map of France or other similar duty; and, further, two of the lieutenants, immediately on quitting the Staff School of Application, are sent to the war depot (*Dépôt de la Guerre*) to gain a familiarity with trigonometrical operations.

The General Officers at their Inspections are required to report specially to the Minister of War on the captains and lieutenants of the staff corps doing duty with the regiments in their districts, both as to their knowledge of drill and manœuvres, and their acquaintance with the duties of the staff. They are to require these officers to execute a military reconnaissance, never allowing more than forty-eight hours for the field sketch and its accompanying report.

Officers of all arms of the rank of captain or under, are permitted to exchange with officers of equal rank in the staff corps; but they must previously satisfy the conditions of the final examinations of the Staff College.

THE BUILDINGS AND ESTABLISHMENT.

The Staff School of Application is situated in Paris, in the Rue de Grenelle, close to the Invalides. Of the ninety officers attending it, sixty lodge in the building and thirty out of it, but all take their meals in the town. Each has, in general, a room to himself. Servants are provided in the proportion of one to about eight rooms. The officers are forbidden to have private servants.

The staff of the school is composed as follows:—

The Commandant, a General of Brigade.
The Second in Command, Director of the Studies, a Colonel or Lieutenant-Colonel of the Staff Corps.
A Major of the Staff Corps, charged with the superintendence of the interior economy and the drills and exercises.
Three Captains of the same Corps, charged with the details of the interior economy of the School, and to assist the Major in the instruction of the Officers in their military duties. The Captains are required to take the direction of a portion of the topographical works on the ground.
A Medical Officer.

Thirteen Military Professors, or Assistant Professors, viz.:—

A Major or Captain, Professor of Applied Descriptive Geometry.
A Major or Captain, Professor of Astronomy, Physical Geography, and Statistics.
A Major or Captain, Professor of Geodesy and Topography.
A Major or Captain of Engineers, Professor of Fortification.
A Major or Captain of Artillery, Professor of the instruction relative to this arm.
A Military Sub-Intendant, Professor of Military Legislation and Administration.
A Major or Captain, Professor of Military Art.
A Captain, Assistant Professor of Descriptive Geography; charged also to assist the Professor of Fortification.
A Captain, Assistant Professor of Topography; charged also to assist the Professor of Geography.
A Major or Captain of Cavalry, Professor of Equitation; he acts under the immediate orders of the Major of the College.
Two Lieutenants or Second Lieutenants of Cavalry, Assistant Professors of Equitation.
An Officer of Cavalry of the same rank, acting as Paymaster to the Riding Detachment.

The Non-Military Professors are:—

Two Professors of Drawing.
Two Professors of German.
A Professor of Fencing.

One hundred and forty-five horses are kept for the use of the student-officers, and eighty-two men belonging to the cavalry to look after them.

Both the studies and examinations at the Staff School hold an intermediate place between those of the Polytechnic and St. Cyr, being less abstract than the former, and higher and more difficult than the latter.

CONDITIONS OF ADMISSION.—ENTRANCE EXAMINATIONS.

The entrance to the Staff School of Application in France is, as is the case in all the French military schools, by means of a competitive examination, or, rather, by the results of three distinct examinations, and by the selection of different sets of successful candidates. *Three* are taken from the students leaving the Polytechnic, who have an absolute right to the three first places in the Staff School, and *twenty-two* are selected from the thirty best students leaving St. Cyr, and an equal number of sub-lieutenants of the line under twenty-five years of age, if so many present themselves. The sub-lieutenants must have one year of service in that rank, and they must make known their request to be allowed to compete for admission to the Staff School to the Inspector General, and, through him, to the Minister of War. It should be added, that their number is generally extremely small.

The usual number of young officers admitted yearly to the school in time of peace is twenty-five, but this number is sometimes considerably exceeded, and we found no less than ninety present. The *three* Polytechnic students select the Staff School after their final examination, and the St. Cyr students make known their desire when the whole are examined by a Board of Examiners, and the thirty best are then selected as competitors for admission into the Staff School of Application.

The sub-lieutenants also repair to St. Cyr, where they are examined separately by the same examiners who have just conducted the examination of the St. Cyr students, and in the same subjects.

Their marks or credits are then compared with those of the St. Cyr pupils; and the relative position of the two sets of candidates is ascertained, and the list of those to be admitted to the School of Application determined accordingly.

These examinations take place before a Commission of Officers, composed of,—

A Lieutenant-General President, appointed by the Minister of War.
The Director or Chief of the Dépôt de la Guerre.
The Commandant of the School of Application.
Four Colonels or Lieutenant-Colonels of the Staff, appointed by the Minister of War.
A Field Officer chosen from among the Officers employed at the Dépôt de la Guerre, as permanent Secretary.

This Commission is also charged with drawing up and proposing regulations for the approval of the Minister of War concerning the interior organization and the course of study to be followed in the

school, and to make changes in the programmes for admission and for leaving the school.

A very detailed account of the subjects of the entrance examination is drawn out, and inserted in the *Journal Militaire*, and the *Moniteur* every year. The following are the subjects:—

(1.) Trigonometry and Topography.
(2.) Regular Topography—the measuring of plane surfaces and leveling.
(3.) Irregular Topography, Plane Trigonometry.
(4.) Military Art and History, including—
  (*a.*) History of Military Institutions at the chief periods.
  (*b.*) Present composition of the French army.
  (*c.*) Organization of an army in the field.
  (*d.*) History of some of the most memorable campaigns, as those of 1796—97 in Italy, and of 1805 and 1809, in Germany.
(5.) Artillery and Science of Projectiles.
(6.) Field Fortification and Castremetation.
(7.) Permanent Fortification.
(8.) Military Legislation.
(9.) Military Administration.
(10.) Manœuvres.
(11.) German Language.
(12.) Drawing.

The marks assigned and the influence allowed to each of these subjects are the same as those given in the final examination at St. Cyr. The entrance examination places the students in order of merit.

THE STUDIES.

All the details of the teaching are in the hands of a Council of Instruction, similar to that of the Polytechnic, and consisting of the General Commandant (President,) the Director of Studies, and three Military Professors, appointed yearly by rotation. Other professors and assistant professors, or officers of the staff of the school, may be called in to assist the Council, but (except in deciding the list at an examination) they have no votes.

This council does not interfere directly with the administration, the common work of the school. It draws up, indeed, the list of lectures, making any alterations in them, or in the books to be used which may seem from time to time desirable. But the officer accountable for the daily working of the school is the Director of Studies. His functions appeared to us to bring him into more constant connection with the pupils than was the case with the director of the Polytechnique. In all the schools the General Commandant and the Director of Studies live in the establishment; but at the *Ecole d' Application* and at St. Cyr the director "examines the methods of teaching, and proposes to the Council of Instruction any modifications or improvements which may raise or quicken the instruction. He inspects the work of the student-officers, both in

and out of the school. He keeps a register of the marks given by the professors, and at the end of every three months brings the sum of them before the General Commandant in a detailed report." In fact, his school functions are not modified, as at the Polytechnic, by a body of able professors.

As already stated, there are fifteen professors, without reckoning those of equitation, and thirteen of them are officers; but the system of *Répétiteurs*, which we have seen so influential at the Polytechnic, does not exist here.

The hours of work are, in summer, *i. e.* from May to November, from six to five, and in winter from eight to five, with the exception of one hour for breakfast and one hour for *étude libre*, which appears to mean very little indeed. From seven to nine hours daily may be taken as the amount, but (as is the case with most French schools) there is a constant change, not only in the subjects taught but in part of the work being *out* and part *in* doors, some really head work, much purely manual. There does not appear to be the same intense application as at the Polytechnic; indeed, the work for three months in the year is almost entirely in the open air, consisting in making plans and military sketches, either in the neighborhood of Paris or in the more distant parts of the country; eight months are devoted to the in-door studies, one month to the examinations.

The in-door studies are entirely conducted in the halls of study (*Salles d'étude*,) in each of which we found parties of twelve or fifteen students seated. They are inspected constantly by the director or some of the professors. None of the regular work may be done in private. It seems everywhere a fixed belief in the French Military Schools that very much would be done idly and ill if done in private. This presents a striking contrast to the feeling on the subject in England.

The severer and preparatory studies of mathematics are supposed to have been completed prior to entrance into the Polytechnic or St. Cyr. Some, however, of the studies of applied science occupy considerable time at the School of Application.

The following analysis will show the time assigned to each branch:—

1. *Astronomy* occupies 1½ hours weekly for the pupils of the first year; afterwards it ceases entirely.

2. To *Applied Descriptive Geometry* a good deal of time is given, but still only by the pupils of the first year. 12 hours a week are spent upon it in the first half year, 10 in the second.

3. *Military Topography* occupies about 10½ hours in the first year, 6 in the second.

4. A good deal of time is devoted to *Field Fortifications*. The junior division, it is true, only begin it in their second half year of study, and then only work at it for 1½ hours weekly. But the senior division are occupied 4½ hours weekly in their first half year, and 7½ hours in their second.

5. *The Study of Military Administration and Legislation* is begun immediately upon entrance. It occupies during both years 1½ hours weekly.

6. *Lectures on Military Art and Tactics* are also given for 1½ hours weekly during both years, and after hearing these lectures the students are occasionally required to write a military memoir on a campaign, descriptions of reconnaissances, or of fields of battle, and to make sketches of ground with accompanying reports. This course was noted by General Foltz, the director of the school, as defective, on the ground that it was too difficult to find a teacher for, or indeed to teach military art; and he thought that lectures on military history, or such works as Napoleon's Memoirs, would be more useful to the pupils.

7. *Drawing* occupies throughout 4½ hours weekly, and great attention is bestowed upon it. We were shown a large number of works done by the young officers of the school. To enumerate some of the most important—there were specimens of objects, with shadows; perspective of the exterior and interior of buildings, with shadows; perspective views of country; machinery drawings, plan, section, and elevation; in fortification, a plan of comparison of a portion of ground with proposed field-works for defense; military bridges; reconnaissance, and memoir of a route, with accompanying notes and sketches, done both on foot and on horseback; plan of a portion of country made with a compass by parties of ten, under the direction of a Captain (for this the trigonometrical points and distances were furnished, and it was filled up by a minor triangulation;) plan of a field of battle, made without points; and a description of the battle.

These drawings were mostly executed with great care, and we were told that the course was fully as much as the student could accomplish in two years. Some parts of it are done entirely in the *Salle d'étude;* sketches are made on horseback in the neighborhood of Paris, always under the direction of the professors, others again at great distances, such as one at Biarritz last year, and the one on which the pupils are to be engaged this year, is the line of operations of Wellington from the Spanish frontier to Toulouse. The two last kinds of work are roughly sketched, and finished at Paris. These summer occupations seem to stand in place of vacations, of which there are none.

(1.) To *Fencing*, three hours a week are given throughout.

(2.) To the *Cavalry Drill* two hours weekly in the first division. It is replaced by *Infantry Drill* in the second.

The studies which none but the senior division pursue are,—

(1.) *Artillery* studies, which occupy 4½ hours weekly.

(2.) *Geography*, meaning chiefly the military geography of a country, with a few lectures on statistics and political economy; these take 1½ hours weekly.

(3.) *Geodesy*, or trigonometrical surveying, also for 1½ hours.

The only strictly literary occupation is the study of German for about three hours per week during the whole time. We were told that a large proportion of the pupils unite among themselves to learn English privately, but no public course is given.

THE EXAMINATIONS.

The students have two examinations to go through in each year; the first commencing about the first of June, the last in November, and each of the first year's examinations is held before a jury consisting of—

(1.) The General Commandant, or the Director of Studies; President.
(2.) The Professor of the Course examined in.
(3.) Two Officers appointed by the Council of Instruction.

The last examination in each year is, of course, the most important, inasmuch as the passage from the Second or Junior to the First or Senior Division, and in part from the Senior into the Staff Corps, is regulated by the results of these examinations; and the value allowed to the last examination in each year is just double of that assigned for the examinations in June.

The examinations of the first year are confined to the subjects of study followed during that year, viz.:—

Descriptive Geometry, Astronomy, Topography, Artillery, Fortification, Military Art and Administration, German, Drawing, Register of Notes and Memoranda.

The professors and members of the jury are directed rigorously to conform themselves to the following scale as regards the marks or credits they award for the oral answers, graphical representations, &c.

0	to 4	bad.
5	to 10	passable.
10	to 13	fair.
14	to 18	good.
19	to 20	very good.

The Co-efficients of influence of the various studies of the first year are as follows:—

					Subdivision of the Co-efficients of the Graphical Representations.	
Descriptive Geometry,	Theory,	4	9		Survey with compass,	1
	Geographical Representation,	3			Rapid sketch,	1½
	Drawing of Machines, Memoir,	1			Itinerary of the first survey,	1½
	Drawing,	1			Itinerary of the second survey,	
Astronomy,	Theory,	4	5		First Topographical Drawing,	½
	Graphical Representation,	1			Second, with relief,	½
Topography	Theory,	4	10		Third, on the scale of $\frac{1}{20000}$,	½
	Graphical Representation,	6				
Artillery,		4				
Fortification,	Theory,	4	8			
	Graphical Representation,	2				
	Memoirs,	2				
Military Art	Theory,	4	7			
	Memoirs, On various questions,	1				
	Memoirs, On surveys,	2				
Total,			43			
Amount carried forward,						

		Subdivision of the Co-efficients of the Graphical Representations.
Amount brought forward,	43	
Military Administration, Theory,	4	5
Military Administration, Memoirs,	1	
Manœuvres,	2	
German,	4	
Drawing,	2	
Keeping of Memorandum Books,	1	
Conduct and Discipline,	1	
Riding and Knowledge of the Horse,	2	Riding, 2
		Hippology,
Total,	60	

As soon as the examinations are concluded, the Council of Instruction prepares a provisory classified list of the students, made out in order of merit from the credits or marks awarded by the Examining Jury in connection with the above-mentioned co-efficients of influence, in a similar manner to that already explained in the account of the Polytechnic School, the student with the largest numerical credit being placed at the head of the list.

This provisory list is submitted to the Consulting Committee of the Staff Corps for transmission to the Minister of War.

In order to pass from the Second or Junior into the First or Senior Division, every Student Officer must have obtained the following marks or credits from the Jury, viz.:—

In Astronomy and Geometry, six out of twenty in each.

In all other branches of theoretical instruction, four out of twenty.

In the classification of the graphical representations in topography, a mean of eight out of twenty, and in each of the other courses a mean of six out of twenty; and as the general result of his various works and of his examinations (the mean of the year being combined with the number obtained before the jury in the proportion adopted by the Council of Instruction,) he must have obtained a number of credits equal to one-half of the maximum (1,200.)*

Every Student Officer who in his oral examination before the Jury has failed in obtaining the minimum stated above is subjected to a fresh proof before the Consulting Committee of the Staff Corps, and if this is not favorable to him he ceases to belong to the school, and must return to his regiment, unless such failure can be attributed to an illness of forty-five days, in which case he may be permitted to double his first year's course of study.

If the second proof be favorable he is retained at the school, but

* There must be some error in the printed regulations on the subject.

placed at the bottom of the classified lists prepared by the Council of Instruction.

The co-efficients of influence for the second year are—

				Subdivision of the Co-efficients of the Graphical Representations, &c.	
Geography and Statistics,	Theory,	4	5		
	Memoir,	1			
Geodesy and Topography,	Theory,	4	10	Survey with the Compass,	1
	Geographical Representation,	6		Reconnaissance,	1½
				Itinerary of the first survey,	1½
				Itinerary of the reconnaissance	
				Drawing of a Fortress and its Environs,	1½
				Reduction of the Drawings,	½
					6
Artillery,	Theory,	4	8	First Drawing of a Military Bridge,	1
	Graphical Representation,	3		Second ditto,	½
	Memoirs,	1		Breaching Battery	½
				Drawing of Artillery Carriage,	1
					3
Fortification,	Theory,	4	11	Defilement,	1
	Graphical Representation,	3		Project of Fortification,	2
	Memoir on a Fortified Place,	2½			3
	Memoir on a Project of Field Fortification,	1½			
Military Administration,	Theory,	4	4		
Military Art	Theory,	4	8		
	Memoir on various questions comprised in drawing up a memoir,	2			
	Memoir on the survey with a Compass, or sketch reconnaissance,	2			
Manœuvres,			3		
German,			4		
Drawing,			2		
Keeping of Note Books,			1		
Conduct and Discipline,			1		
Riding and Knowledge of the Horse,			3	Riding,	2
				Veterinary Art,	1
					3
Total,			60		

The examinations of the students of the Senior or First Division is made in a similar manner to that already described for the Junior Division, but after they are concluded, and prior to these students being admitted into the Staff Corps, they are subjected to another examination before the Consulting Committee of the Staff Corps, consisting of—

3 Generals of Division on the Staff.
3 Generals of Brigade.

3 Colonels of the Staff.
5 Lieutenant-Colonels, including the Secretary.

The professors belonging to the school may be called in to assist at this examination, and when it is concluded the Consulting Committee proceeds to the definitive classification of the Student Officers of the First Division by causing the following documents to be placed before them, viz.:—

The register of the notes of each Student Officer.

Tables of the value of their work; the classified list of passage to the First Division, and the provisionary list for leaving, recently prepared by the Council of Instruction. The numerical credits obtained in these two classifications are added (each sum being halved) to the definitive classification prepared by the committee. The total is divided by two, in order not to exceed the regulated limit of 1,200 credits for the maximum.

Every Student Officer who, in this examination for leaving, has not obtained the half of the maximum number of numerical credits is considered to be inadmissible to the Staff Corps.

This classified list, prepared by the Consulting Committee of the Staff Corps, fixes the position of the Student Officers in order of merit, and according to this order of merit they enter the Staff Corps. The committee reports to the Minister of War the names of the Student Officers that are not eligible for the Staff Corps.

The first two or three places, we were told, are always remembered as marks of distinction, but the honor does not descend lower, as in the intense competition of the Polytechnic.

Students belonging to the First Division may also be permitted to double the second year's course of study on account of illness; but in no case can an officer be permitted to remain more than three years at the school.

MILITARY ORPHAN SCHOOL

AT LA FLECHE.

THE *Collége* or *Prytanée Militaire* appears, in point of studies, to differ from the schools that have just been described, chiefly in its having only one department for the elder pupils, the scientific, with merely occasional subsidiary lessons in grammar and literature.

The institution is a school for boys between the ages of ten and eighteen; no one under ten or above twelve years old can be admitted: and no one can commence a new course at the school after completing his eighteenth year.

The prescribed instruction comprise the following courses:—

Humanities (Latin, &c.)
History and Geography.
German.
Mathematics.
Physical Sciences.
Natural History.
Figure Drawing.
Linear Drawing.

And the general object of the courses is to qualify the pupils to pass the examination for the degree of Bachelor of Science.

The pupils also go through military and gymnastic exercises, and learn to swim.

The school is under military discipline, is governed by a general officer of the staff corps or a colonel in active service, as commandant and director of studies, and by a lieutenant-colonel or major, with the title and functions of second in command and sub-director. In addition there are four officers, twenty-three professors and teachers, and eighteen *répétiteurs*.

The yearly charge for paying pupils is 850 francs, and the cost of outfit about 500 francs; but there are 400 free and 100 half-free places (400 *bourses* and 100 *demi-bourses*) granted by the state in favor of the sons of officers, the order of preference being regulated as follows, those who are orphans on both sides having the first claim, and those who have lost their father, the next:—

1. Those whose fathers have been killed, or have died of wounds received in action.
2. Those whose fathers have died in the service, or after retiring on a pension.
3. Sons of fathers who have been disabled in consequence of wounds received in action.

Sons of non-commissioned officers or of private soldiers who have been killed or have been disabled in action, who have been placed on the retired list, or have been discharged after twenty years' service, may also be admitted, as a special mark of favor.

The candidates undergo an examination, not, however, for the purpose of competition, but merely to show that they are qualified to enter the classes.

The school is inspected annually by a general officer sent by the war department, as also by an officer of the commissariat. There is no sort of engagement or expectation that the pupils should enter the military service. The nature of the studies holds out some inducement to them to compete for admission at St. Cyr or the Polytechnic; and in the examination for entrance at St. Cyr, it is stated that the sons of military men have the privilege of being raised fifteen places in the list of the order of merit. An officer's or soldier's son from La Flèche would, in case of 300 candidates being admitted to St. Cyr, be able to claim admission, if he came 315th on the list, to the exclusion of the candidate who stood 300th.

SCHOOL OF MUSKETRY.

THE School of Musketry, formed by the Ministerial Order of 29th March, 1842, was only intended at first to supply instructors to the ten battalions of Chasseurs who were armed with rifles. The results of its establishment were, however, found so valuable, that the benefits of the instruction it afforded were by degrees extended to the whole army.

In 1845, the Duc d'Aumale, who had taken a special interest in the improvement of fire-arms and the better instruction of the soldier in their use, was nominated Inspector-General of Schools of Musketry. Besides the chief school at Vincennes, others were formed in the principal garrisons; and eventually a regimental School of Musketry was established in every regiment of infantry.

Some changes have been made in the system established under the Duke. The School of Musketry at Vincennes has only been regularly organized on its present footing since 1852. A portion of the fortress affords the accommodation required for the theoretical instruction, while the Polygon offers admirable facilities for practical instruction and target practice.

The Staff of the School consists of,—

A Commandant, a Lieut.-Colonel of Infantry.
An Instructor in Musketry, a Major of Infantry.
A Professor, a Captain of Artillery.
An Assistant Professor, a Captain of Artillery.
A Sub-Instructor in Musketry, a Captain of Infantry.

Each regiment sends an Officer (a Sub-Lieutenant or a Lieutenant) to Vincennes, to go through the course of instruction. The course commences on the 1st of March, and lasts four months. Two hours a day three times a week are devoted to lectures on the construction and use of fire-arms, and the theory of projectiles. Each officer is required to complete a certain number of drawings of the separate parts of arms. At the termination of the course, certificates are given, and, if favorable, go towards the officer's claim to be promoted "*au choix.*"

We were conducted over the rooms of the fortress set apart for the school by the officer charged with the Theoretical Instruction (Captain Févre, of the Artillery.) They consist of a large paved

room, where the officers perform their small-arm exercise in bad weather; of the study-room, in which the drawings are executed; of a lecture-room or amphitheater; of the library, chiefly supplied with technical works on arms; and of a model-room, containing a very good collection of French and foreign arms, and of portions of arms, to illustrate the lectures. There are, besides, private rooms for the instructors, and a room for the orderlies. On the ground floor a small forge has been fitted up for the purpose of giving practical instruction in some of the details of the manufacture of arms.

To produce accurate marksmen is not the only object of the School of Musketry. Its staff may be considered a description of standing committee, to whom inventions in arms and ammunition are submitted, to have their qualities practically tested. On the day of our visits experiments on the relative merits of three forms of balls were being carried on, which we witnessed.

Quitting the fortress by a bridge over the ditch, in an angle of which the Duc d'Enghien was shot, we entered on the Polygon or practice ground. In a few minutes two detachments of troops, one from the Chasseurs de Vincennes, the other from the 20th regiment of the line, arrived and took up their ground in front of the practice butts. Of the balls between which comparisons were to be made, one was proposed by M. Minié, who was himself present, another by M. Nessler, the third was named the ball "*de la garde.*" There were six targets in line in front of the butt; the Chasseurs fired at three of them, and the 20th regiment at the other three. A trench runs along parallel to the butts, and at a few yards in front of them. The line of targets is in the space between the trench and the butts. The trench gives cover to the range party, one of whom is stationed opposite to each target, in a rude recess cut into the side of the trench, to afford shelter in wet weather. Each time a target is struck, the man opposite to it raises his banderol, which is then seen by the firing party, and acknowledged.

The trench is continued to some distance beyond the butts, and is there met by another trench at right angles to it; so that one may go up from the firing party to the range party without any risk.

On the cessation of the firing, the officer in command of the range party numbered the hits in each target. He marked separately the hits where the balls had arrived sideways (shown by the form of the perforation,) a very important consideration in comparative experiments with oblong balls.

Prizes and honorable mentions are bestowed annually on the best shots. The number of the regiment and the names of the men thus distinguished are inserted in the official military journal.

MILITARY NAVAL SCHOOLS OF MEDICINE AND PHARMACY.

I. IMPERIAL MILITARY SCHOOL OF APPLICATION OF MEDICINE AND PHARMACY AT PARIS.

This school, which is located at Paris, at the military hospital of Val-de-Grâce, is under the control of the Minister of War. Its design is to introduce the pupils in the medical service of the army to an actual exercise of their skill, to complete their practical education, and make them acquainted with the regulations which govern the army in its relation to the sanitary service.

Admission to the School of Application as resident physicians and pharmaceutists, is gained by passing successfully a competitive examination. These examinations are held at Paris, Strasburg, and Montpelier, at uncertain periods, as the wants of the service may require.

For admission to the examination, the candidate for employment as resident physician must have his name enrolled in a bureau of military superintendence, and satisfy the following conditions:—1st. Be a native of France; 2nd. Be not above thirty years of age at the time of the examination; 3rd. Have received the degree of doctor of medicine from one of the medical faculties of the Empire; 4th. Be free from any infirmity that disables from military service; and 6th. Subscribe a pledge of honor that he will devote at least five years to the military sanitary service. The candidates are subjected to an examination in pathology, medical therapeutics, anatomy, and practical surgery. Candidates for the office of resident pharmaceutist must also be natives of France, be not above thirty years of age, have a diploma of pharmacy of the first class, be free from every disabling infirmity, pledge themselves to at least five years service, and pass an examination upon the materia medica, chemistry, and pharmacy.

During their continuance at the School, they receive a fixed annual salary of 2,160 francs, and an allowance of 500 francs for the first expense of uniform. After spending one year at the school and passing a satisfactory final examination, they receive the brevet rank of medical or pharmaceutical aid-major of the second class.

There is at Strasburg, in connection with the Medical School, a Preparatory School, designed to prepare for the degree of doctor of medicine the pupils belonging to the sanitary service of the army. It is annually supplied with pupils, who, without having passed the usual course of matriculation, are enabled to satisfy the conditions requisite for admission to the first grade of a doctorate. Every pupil of the preparatory school, has the right of admission to the Imperial Military School of Application.—*Decrees of* 13*th of Nov.*, 1852, *and* 28*th of July*, 1860; *Acts of* 18*th of June, and* 15*th of October*, 1859, *and* 4*th of August*, 1860.

II. IMPERIAL NAVAL SCHOOLS OF MEDICINE AND PHARMACY.

These schools, located at Brest, Toulon, and Rochefort, are under the control of the Minister of the Marine; their design is to prepare sanitary officers for service in the vessels of the imperial marine.

The posts of surgeon, or pharmaceutist, of the third, second and first classes are assigned on examination, according to order of priority determined by a medical jury. For admission as student in these schools, after attaining to the first grade of the third class, it is necessary to be at least sixteen years of age, and not above twenty three, to produce a diploma as bachelor of sciences, to prove French nationality, and to be exempt from every infirmity that can cause unfitness for the marine service. Examinations for filling the vacancies in each school commence on the 1st of April, and 1st of October, annually.

The instruction is continuous. The libraries, cabinets of natural history, the botanical gardens, anatomical theaters, chemical laboratories, cabinets of natural philosophy, are at the disposition of the students. The candidates admitted, receive cards of membership. They are required to pay the treasurer of the library a sum of 50 francs, which is devoted to its maintenance.—*Ordinance of* 17*th July*, 1835, *and* 15*th May*. 1842.

THE IMPERIAL NAVAL SCHOOL AT BREST.

This school, located at the Road of Brest, on board the ship "*La Borda*," and under the control of the Minister of the Marine, is designed for the instruction of youth destined for the corps of state naval officers. Candidates are admitted to this school after a public examination, which occurs annually. For admission to the examination, they must prove; 1st. By the production of the records, that they are French by birth or naturalization, and that on the 1st of January of the year of the examination, they were at least fourteen years of age, and had not passed the maximum of seventeen years; 2d. By the certificate of a physician, that they have been vaccinated, or have had the small-pox, and that they have no infirmity that disables them from the performance of marine duty.

The matriculation of the candidate is effected between the 1st and 24th of April, at the prefecture of the department in which the domicil of the family is located. The examination is made at the principal office for examination nearest to that domicil, or to the college where he has been educated; the choice as regards the place of examination must be made known at the time of matriculation.

There is required for admission into the school, a knowledge of arithmetic, algebra, geometry, plane trigonometry, applied mathematics, natural philosophy, chemistry, geography, the English language, and drawing, in conformity with the course of study pursued at the lyceums. The candidates must prepare a French composition, a translation from the Latin, an exercise in English, a numerical calculation in plane trigonometry, a geometrical drawing, and the off-hand sketch of a head. These compositions are done at Paris, and the principal towns of the departments simultaneously, on the 2nd and 3rd of July. The oral examinations are commenced at Paris on the 2nd of July, and repeated at the other towns in succession as previously announced. The oral examinations are of two grades; the lowest serving to determine whether the candidates are sufficiently well prepared for admission, the higher—to which only those are subjected, who have successfully passed the first—being

the decisive one, and together with the compositions, determining the final classification in accordance with the order of merit.

The course of study continues two years, which are passed at the Board of Brest on the ship "*La Borda.*" The expense of board is 700 francs, and of the outfit, about 500 francs. A grant of the whole or half of the amount of the expense, may be made to young men without fortune. The insufficiency of the resources of a family for the maintenance of a pupil in the school, must be authenticated by a resolution of the municipal council, approved by the prefect. There may also be allowed to each beneficiary, at his entrance into the school, the whole or the half of his outfit. Application for this assistance must be made to the Minister of the Marine at the matriculation of the candidate.

The pupils that have passed the examinations of the second year in a satisfactory manner, are known as naval candidates of the second class.—*Law of 5th June*, 1850—*Decree of 19th January*, 1856—*Acts of Sept.*, 1852, *and 1st January*, 1861.

SCHOOL OF MILITARY GYMNASTICS NEAR VINCENNES.

THE practice of gymnastics is an essential part of the training both of officers and men in the French army, and constitutes a portion of the regular exercise in every military school. There are also several schools specially devoted to this department of physical education, and one styled the Imperial School of Military Gymnastics at the Redoute de la Faisanderie, part of the fortifications near Vincennes, may be regarded as the Normal School for training both officers and privates in order to act as monitors or instructors in their respective regiments and battalions. The following account of the instruction given, is abridged from an article in the *New York Tribune*, under the heading, "How the French and the English make their Soldiers." The writer says that Military Gymnastics, in the form and to the extent taught in this school, is exclusively French, and is thought to have an important bearing on the more frequent and deadly use of the bayonet in future warfare.

About three hundred privates and officers compose the School of Military Gymnastics near Vincennes, where three professors of the science and art of gymnastics give a course of practical instruction for about six months each year. The school is under the same regulations as the School of Musketry—each colonel being responsible for the instruction of his regiment, and the lieutenant-colonel directs the application of the rules and regulations.

I. ELEMENTARY GYMNASTICS.

The gymnastic exercises are divided into "elementary gymnastics," and "gymnastics applied," that is, applied to special military purposes. A general progression regulates all the exercises.

The men are divided into three classes. The third class comprises all the recruits. These are exclusively practiced in the first lessons of elementary gymnastics during the first fortnight of their enlistment, and before they proceed to regimental drill. The first class consists of those who are proficient in the first four lessons of the general progression; and the second class, of those who are preparing for the first. The first class practices twice a week; the second, three times a week; the third class twice a day, until the men have commenced their regimental drill, and then once a week. Each practice lasts one hour and a half. "Returns" are drawn up recording the zeal and progress of the men, as in musketry instruction; and the captain instructor of gymnastics has to send in, every month, to the lieutenant-colonel, similar returns as to

the general progress of the instruction, so that the number of effectives of each company may be accurately known.

None but the prescribed exercises are permitted by the instructor. He must never allow the men to attempt any extraordinary or exaggerated feats, that might cause accidents. His aim must be to develop the strength, agility and dexterity of the soldier by a wisely regulated exertion, and inspire him with that self-reliance which the various occasions of his military life may demand. He must strive to rouse his pluck and emulation by rendering the exercises as agreeable and as easy as possible, taking all necessary precautions to prevent him from injuring himself or becoming discouraged. He must never forget that the perfect safety of the soldier under training, the pleasure of the various exercises, and, above all, the soldier's own desire to excel, are the first and secret elements of success in gymnastics. Harsh treatment must be carefully avoided, much more anything like turning his efforts into ridicule when he fails, or punishing him for involuntary awkwardness. In conclusion, he must not expect more than regularity, precision, and relative perfection in these exercises, to which a military form has been given merely to facilitate their study and their application to the whole army.

The men practice in their fatigue dress, in squads of ten or fifteen, and are provided with belts.

The first exercises are intended to make the body supple from head to foot, turning the head from right to left, forward and backward, or merely toward right and left, bending the body, raising the arms vertically, with and without bending them; flinging out the right or left arm, fists clenched, and describing a circle of which the arm is the radius.

No soldier marches so easily as the French. It is the result of his method of learning to march. In the moderate and quick cadence the foot comes flat to the ground, the point of the foot touching it first; in the running cadence the movement is an alternate hopping on the points of the feet. It is obvious that this mode of teaching to march must enable the soldier to avoid the great cause of universal bad marching and walking, namely, bringing the heel to the ground, thus shaking the whole body, especially the spine, and consequently distressing the brain and lungs. By the great elevation of the legs the soldier must habituate himself to bringing the toes first to the ground, instinctively, to avoid the shock, especially in the running cadence. During the practice the soldier repeats the words "*one—two*," as each foot comes to the ground, in order to practice the lungs at the same time, and also to give a rhythm to the performance.

In order still more to direct locomotion to the fore-part of the foot, so essential to good and easy marching, there is the following practice:—1. Attention. 2. Flexion of the lower limbs. 3. Commence. 4. Cease. At the second command the soldier brings both feet together, throwing the weight of the body forward. At the word *commence*, he slowly lowers his body by bending his hams, so that the thighs touch the calves of the leg, the arms falling beside the body, the weight of the body being entirely thrown on the points of the feet. He then gradually rises to the erect position.

There is also what is called the "gymnastic chain." Circles are traced on the ground contiguously; the men are posted in these circles, in a single rank, three paces apart. The instructor commands:—1. Squad will advance. 2. Double. 3. March. 4. Halt. At the first word the soldier throws the whole weight of

his body on the right leg. At the word *march*, he throws the left foot smartly forward, the leg slightly bent, bringing the point of the foot to the ground, thirty-nine inches from the right, and so in like manner with the right, always keeping the weight of the body on the leg which feels the ground, allowing the arms to take their natural motion for equilibrium. The first man (a monitor, one of the best trained) runs successively through all the windings of the chain of contiguous circles without stopping; the others follow, preserving the distance. When the men meet each other at the intersections of the circles, they shorten or lengthen the pace, so as not to jostle each other, and so that two men shall not pass by the same interval.

To deliver a thrust or a blow with the bayonet, sword, or fist to the best advantage, requires training of the subsidiary muscles, and such scientific practice as places the body in the best position to aid and intensify the effect. This is done by the "Pyrrhic Exercise." The command is:—1. Pyrrhic Exercise (right or left limb forward.) 2. Ready. 3. March. 4. Halt. At the word *ready*, the soldier faces to the left, carries the right foot forward, the heel sixteen inches from the hollow of the left foot, the right knee bent, the left leg stretched, the right arm extended forward, the fist clenched, on a line with the shoulder, the nails slightly upward, the left arm in a line with the left side and but little bent, fist clenched, and about six inches from the thigh, the nails toward the thigh, the upper part of the body inclined forward, the head erect, the eyes looking to the front, the left shoulder lowered. At the word march, the soldier straitens his body, bringing the right heel near the hollow of the left foot without touching the ground, turns at the same time his right forearm, so that describing a circle from below upward, the fist lightly touches the right breast, then flinging the fist smartly forward, the nails a little upward, and advancing the right leg to about twenty-five inches, the foot striking the ground with force, or an "attack," as we call it in sword exercise, the upper part of the body inclining forward, the left leg stretched, the foot flat, the left arm turned outward and along the thigh as before. These movements are continued until the words "company—halt" are given, when the soldier faces to the right and comes to attention. The left arms are practiced in like manner, and a rhythm is given to the performance by the repetition of the numbers 1, 2, 3, by the soldier.

A soldier must not be easily knocked off his legs; so there are six positions for the practice devised to teach the soldier how to maintain his equilibrium. He stands alternately on the right or left leg, bending the other against the body with his locked fingers, or he stands on one leg, the other bent behind, or he comes slowly to the kneeling position and springs up smartly, flinging his arms suddenly above his head, the nails turned inward, and then comes to attention, or he bends forward on one foot, or backward in like manner, and to the right or left, all on one foot.

The elementary development of the muscles forms a most important part of the training. By word of command the soldiers strike their breasts with the right or left fist—strike out with the right and left as in boxing—support cannon balls in the hand, one or both arms extended, and hurl the balls to a distance. They fling an iron bar, held by the middle; they support a heavy club in every possible position, at the shoulder, behind the back, one with the left hand, another with the right, at right-angles, or two together, one in each hand. They swing the club horizontally and overhead, or vertically and behind, or round and round the body.

Preparatory to leaping. the proper muscles must be taught their necessary contractions, and this is done to the words of command—"Simultaneous flexion of the legs," "Simultaneous flexion of the thighs and legs," whereat they hop on the right or the left leg singly, and then on both together. They are practiced in advancing on the position of kneeling on one leg alternately, obviously a very useful mode of progression for a skirmisher in stealthily changing position behind a low wall or a hedge.

They are taught to walk systematically on the heels alone and on tiptoe, and to fling a cannon ball with the foot by means of a strap attached to it. As practice alone can habituate us to the proper inclination of the body in ascending and descending, both these modes of marching are carefully taught, attention being fixed to throwing the weight of the body on the point of the feet in the former, and on the heels in the latter.

Their wrestling takes every shape and mode of contest. With extended arms, the fingers interlocked, the left leg advanced, they push against each other; or, holding each other by the hands or by the wrists, they pull against each other; or, each man holding his left wrist with his right hand, the thumb underneath, seizes with his left hand the wrist of his antagonist, and then at the word "wrestle," he pulls or pushes uniformly or by jerks, to the right, to the left, forward, to the rear, upward and downward, striving to displace his antagonist.

Furnished with appropriate handles, with a short cord attached, they pull against each other, each striving to drag his antagonist with one hand, then with both hands; and then three wrestle together in like manner, the central man pulling or resisting the outer two, or both of these pulling against him in opposite directions.

Then two wrestle in a sitting posture. They sit, closing the legs, feet to feet, and sole to sole, with the aforesaid handle and cord between their feet, and at the word of command pull away, striving to raise each other. As soon as one is raised the contest ends, and the victor holds the handle in his left hand. The instructor then makes all those wrestle together successively who have won the handle, until only two remain, and then ascertains the strength of these two by a dynamometer, and makes a note of it.

The last of the elementary exercises are those of traction, or drawing against each other, holding on by a rope, either in pairs, or several together pulling against a fixed point, which may be a dynamometer, indicating the force of the combined pull resulting, or the men are divided into two squads and pull against each other.

As most of these exercises admit of a rhythm or cadenced sound emitted by the men themselves, this vocal accompaniment is strongly recommended. It certainly gives additional animation to the scene. Indeed the cultivation of the voice is considered eminently essential in the course of gymnastics. Singing exerts a salutary influence on the chest, and, moreover, it is incontestable that it will be the means of powerfully acting on the *morale* of the French soldier, by teaching him songs of patriotic and martial import. The singing-lesson at which I was present was particularly interesting. The system is one recently invented, wherein the ordinary notes are represented by arithmetical numbers—thus occupying about one-third of the usual space. Pointing by means of two canes to each representative number is all that is required by the instructor. The pupils, about 300 men and officers, intoned the notes with admi-

rable precision. When the instructor opened out the canes they made a crescendo—swelling to the loudest—and when he closed them gradually it was a beautiful diminuendo, "in linked sweetness long drawn out." There was then sung a concerted piece in two parts, extemporized by the highly-gifted Commandant, who figured it on the blackboard. It was at once most accurately sung—first and second so admirably concerted that the whole seemed as it were an organ of human stops—alto, tenor, and bass most harmoniously blending.

Such are the elementary gymnastics of the course.

II. APPLIED GYMNASTICS.

The exercises of applied gymnastics must be directed with extreme prudence. Care must be taken by the instructor that the emulation of the pupils should not degenerate into a spirit of rivalry, instigating them to dangerous efforts.

During cold weather they must abstain from executing leaps that require violent efforts; at all times those who are not perfectly disposed should not be required to leap at all. Carelessness and inattention to the rules can alone cause those accidents apprehended in these exercises.

The dimensions of the obstacles to be leaped over must be gradually increased; but no downward leap must ever exceed sixteen feet—five meters. Such is the regulation; but really to leap down sixteen feet seems no small matter, considering that the height of an ordinary room—some ten or twelve feet—would make the nerves tingle if we had to leap down that height; however, the French soldiers perform such leaps with ease, and therefore we must conclude that all Anglo-Saxons here or elsewhere can "go and do likewise."

The words of command are: 1. Attention. 2. Forward—leap—one, two, three. At the second word, the man closes the points of the feet; at the word one, he stoops on his lower extremities, slightly raising the heels and stretching his arms to the rear, the fists clenched; he then rises again, the arms hanging naturally down. At the word two, he repeats the movement; at three, he recommences the same movement, stretches the hams vigorously, throwing his arms forward, leaps the distance, or over the obstacle, falls on the point of his feet, stooping down, and then comes to attention.

The same principle is observed in all leaping, whether to a height, downward, or forward and downward—the only difference being in the position of the arms. In leaping upward, the arms are flung overhead to aid the ascent—the same in a downward leap; but if the leap be forward and downward, the soldier begins with his arms in advance, and then places them perpendicularly for the fall. The reverse takes place when in leaping forward and upward.

Thus they practice leaping in every possible direction—upward and downward combined—upward, forward, and downward—to the right or to the left—to the right and to the left and downward combined—the arms being directed accordingly. They leap backward precisely in the some directions, and according to the same rules. In leaping backward from the top of a wall, the man first takes a glance at the descent, turns, closes his feet—the heels projecting over the wall, stoops—the upper part of the body being forward, places his hands outside his feet and seizes the edge of the wall, the four fingers above, the thumb underneath, and thus flings himself backward, his arms overhead. When there is width as well as depth in the backward leap, the body and the legs are flung off almost horizontally.

The running leap is performed in a similar manner—the run being quickened

more and more up to the moment of springing forward. Some of the leaps I saw performed were from fifteen to twenty feet. As a complement to these leaping exercises, the ground may be prepared with various objects to leap over, such as benches, tables, heaps of stones, &c.

The men are also progressively practiced in all these leaps, carrying their arms and baggage. In such cases the downward leap must be restricted to thirteen feet. The soldier holds his rifle balanced at the trail with the right hand, the muzzle slightly raised, so as to prevent it from touching the ground; he holds his sword (as the French soldier has a sword) with his left hand. When the soldiers have become familiar with leaping, the difficulty is increased by rendering movable first the point of departure, and then the point of the fall, and, finally, both these points are made movable. To leap from a body in oscillation, the soldier leaps at the moment when the body is sinking. There is great danger in leaping from an object in rapid motion. In case of necessity, the soldier must face in the direction of the motion, and at the moment of quitting it he must lay hold of it, shortening his arms, and so push himself backward, lengthening his arms.

It is a general principle that in leaping from a height of any extent, the soldier should avail himself of anything at hand to diminish the shock of the fall.

The circumstances in which leaping must be resorted to are often unforeseen, and require prompt decision; it is therefore important that the men should be taught the following principles—useful to everybody—to apply them spontaneously on all occasions:—

First. To form a rapid judgment of the obstable, and also of the ground on either side. We scan the ground in advance of the obstacle, in order to make a good choice of a footing for the leap; if the ground is too smooth the foot may slip; on soft ground there can not be a good footing for the leap. By scanning the ground beyond the obstacle, we select our landing-place, and we foresee what difficulties we shall meet with. A difference of level between the point of departure and the fall modifies considerably the extent of the leap.

Second. During the leap the breathing must be restrained, and the air with which the lungs have been previously filled must be expired the moment the man reaches the ground.

Third. In leaps in width and height, fling out the clenched fists in the direction the body is to take, so as to augment the impulse given by the legs.

To prove the utility of this principle, the men, in leaping, sometimes hold in each hand a grenade of two-pounds weight, or a four-pound shot; with this auxiliary the width of the leap is augmented.

Fourth. In downward leaps, raise the arms vertically as soon as the body begins to descend, in order that the body, reaching the ground on the point of the feet, may sink vertically without losing its equilibrium. If a man leaps into water, he places his arms at his side, his hands on his hips, the feet close together, the points of the feet lowered, the body stiff and rigid.

Fifth. During the whole time of the leap keep the arms in the parallel position they have at its commencement, in order to preserve the equilibrium of the body.

Sixth. In forward or wide leaps incline the body forward, in order that the oblique action of the legs on the body may be more efficient.

The recommendation to precipitate the last movements of the run preceding the leap, has the important advantage of enabling the soldier to incline his body as much as possible.

Seventh. Fall on the point of the feet, the legs being close together, bending all the articulations of the body from above downward, in order that the shock be not transmitted to the head without being lessened and attenuated by numerous decompositions of the force. The articulations of the feet concur efficaciously with this result, and it would be dangerous not to avail ourselves of them by falling on the soles of the feet, especially the heels, as previously explained.

Eighth. Avoid too rough a fall by giving to all the articulations a general and supple "setting up," so as to make a light bound on landing.

Ninth. On landing avoid all useless motion, allow the muscles to relax; their continued contraction and rigidity would interfere with the body's equilibrium.

They also practice leaping with poles. These are of different dimensions, beginning with the smallest—not longer than the rifle—and finished with long ones from nine to twelve feet in length. He then seizes the pole higher or lower, according to the distance of the leap. Of course perfect success in this exercise depends greatly upon the energy of the effort, and the long and rapid run by which it is preceded. They also leap with two poles together from a height, the poles being planted parallel and about two feet apart.

Suspension-bars are made subservient to the training of the French soldier. This exercise enables him to use his body as he pleases, in any possible position, provided he can get hold of anything. Its beautiful and splendid result is extraordinary strength of arms, legs, hands, and fingers. Indeed, these suspensions of the body by the hands, the elbow, the legs, by one hand, one leg, one finger, in every possible position, show how the men are prepared for the thousand casualties of the assault.

They climb ropes after the manner of sailors, and horizontal beams are raised at various heights from the ground, in which they learn to preserve a perfect equilibrium—sitting, moving along them by the hands, supporting the body, which is free to fall, and, finally, walking erect upon them like a rope-dancer without his balance-pole! In these ticklish positions they meet and pass each other—simulate a fall and recover; the beams may be inclined or even set in motion, it matters not—they hold on and do their work equally well—and drop to the ground without injury.

They are taught to pick their way over scattered stones or stakes driven into the ground; and it has even been thought expedient to teach them how to walk systematically on stilts.

They are taught swimming—all its necessary movements before they go into the water; and many, I was told, strike out at once, at the first trial, thus proving the physiological or anatomical efficacy of the well-considered mode of tuition. In the water they are practiced in performing the feats required in actual warfare, carrying their arms and accoutrements in a variety of ways, according to the supposed circumstances of the campaign.

Of course, if the men are taught to swim they must be sent regularly into the water. This regulation, therefore, insures personal cleanliness—the first rule of health, which is much needed in all armies. The morality of most armies is generally above the average; it should naturally be less—as nothing conduces more to long life than exercise, regular hours, and a rational discipline, But cleanliness, personal cleanliness is wanting, and we have to deplore the consequences.

With a view to escalading, the French soldier is assiduously trained in all the

shifts of ladder-mounting—with ladders of wood and ladders of rope—and he becomes as good as a sailor in pulling himself up a rope, either looped, knotted, or smooth, from the ground to any reasonable or unreasonable height. If a scaling-ladder be not at hand, a tent-pole or any pole will do to enable him to get to the top of a wall or the crest of a parapet. He is actually taught nine different modes of performing this achievement so flattering to the ambition of the French soldier.

The scaling of a represented turret was something beautiful to see. "In the twinkling of an eye" or "done in no time," can alone describe the rapidity of the exploit.

Every appliance may, however, be wanting on certain occasions in war—it matters not—the French soldiers are taught how to mount a wall without any instrument whatever—with their feet and the hands and the fingers alone. Bullets and cannon balls leave holes and indentations in the hardest walls—these are represented on the walls of the Gymnasium—and thus they practice this last resort of the resolute and determined besiegers. If there be no holes—no *points d'appui* for the ascent—what then? Why, then they build a *pyramid of men*—four men stand as a base, two or four more perch themselves on the shoulders of these, and then one mounts to the top on the shoulders of the latter by way of apex!

They have adopted all the fetes of the *trapèze*, as performed by acrobats. These tend to strengthen the arms and promote that self-reliance and confidence which are the prime elements of a good soldier. Some of their swinging leaps with the *trapèze* were prodigious, from one end of the long gymnasium to the other, where they alighted, and caught on the top of the wall, and descended to the ground, with hands and fingers, by mimic bullet holes, as before described.

Flying leaps on and over a wooden horse are practiced in every possible direction, and the French cavalry are required to be able to leap on their horses from the rear while galloping, and to leap over a hedge or barrier together with the horses, but on foot, holding the reins! It is impossible to believe that very many can do this; but that is the aim, and the higher the aim the greater the effort, and something worth having is sure to be done, even if we fail of the highest attainment.

The most laborious of the practices is probably that of carrying, at the top of their speed, all the implements of war, fascines, sand-bags, gabions, projectiles, &c., whose weight is progressively increased from twenty to fifty pounds. They must also practice carrying ladders, beams, caissons, dragging gun-carriages, &c., and they are equally habituated to carry rapidly and skillfully the wounded from the field of battle, by placing men on litters, or any substitute at hand, in the gymnasium.

Sword exercise, bayonet exercise, boxing and fencing are also taught, but only the rudiments. In the regiments and battalions they have more opportunities of perfecting themselves in these accomplishments.

Such is a succinct account of the military gymnastics of the French. The 300 various fetes and practices have only one object in view, preparation for the possible and probable casualties of war, but they have, meanwhile, the positive and immediate effect of giving the men the utmost freedom of motion, *aplomb*, self-reliance, and that very useful self-estimate in the soldier, namely, that he is superior to every other in the world. It will take a vast deal to knock that conceit out of him.

REMARKS ON FRENCH MILITARY EDUCATION.

THE English Commissioners in their Report on "The best Mode of Reorganizing the [English] System of Training Officers for the Scientific Corps, together with an Account of Foreign and other Military Education," close with the following general remarks on French Military Education:—

THE following summary may close our account of French Military Education.

1. The French army combines a considerable proportion of officers professionally educated, with others, who form the majority, whose claims to promotion consist in their service, proved ability, and conduct. One-third of the officers in the line, two-thirds of those in the scientific corps, and the whole of the staff, receive a careful professional education; the remainder are taken upon the recommendation of their superior officers, from the ranks. But it was stated to us expressly that such officers do not often rise above the rank of captain.

2. There are no junior military schools in France, and no military education commences earlier than sixteen. This is the very earliest age at which pupils can be received at the Polytechnic or at St. Cyr, and the *usual* age is later; whilst in the case of the Special Corps, strictly professional education does not begin till twenty or twenty-one. The best preparation for the military schools is found to be that *general* (in France chiefly *mathematical*) education which is supplied by the ordinary schools of the country, directed as these are and stimulated by the open examinations for admission to St. Cyr and the Polytechnic.

3. The professional education for commissions in the line is that given at the school of St. Cyr. A fair amount of mathematics is required at entrance, but the chief instruction given at the school is of a professional character. Active competition, however, which is the principle of all French military education, is kept up amongst young men educating for the line by the competitive entrance to the school, by the system of examinations pursued in it, and in particular, by the twenty-five or thirty places in the Staff School which are practically reserved for the best pupils on leaving.

4. In the Staff School itself the competitive system is acted upon; there are strict examinations, and the pupils are ranged in the order of merit on leaving the College.

5. The officers of artillery and engineers may be said to be in quite a peculiar position in France, owing to the high education given at the Polytechnic School. The consequence is, that the preparatory education of French artillery and engineer officers is of the highest scientific character. We have already spoken largely on this point, and need do no more than allude to it.

6. We may remark, that preparatory military education in France is mainly mathematical—at the Polytechnic almost wholly so. The literary and classical elements, which enter so largely into all education in England and Prussia, are in French military education very much thrown aside. Lectures in military history and literature are said, however, to succeed at St. Cyr.

7. The system of State foundations (*Bourses*) existing in the Polytechnic and St. Cyr, and affording a curious parallel to the military foundations in the Austrian schools, requires some notice. Every pupil, in both the Polytechnic and St. Cyr, who can prove poverty, is entitled to State support, either entire or partial. At the present time, not less than one-third of the students in each of these schools receive such maintenance. The system of civil *Bourses* is of old standing in France; most of these were destroyed at the Revolution. They were renewed and greatly devoted to military purposes by Napoleon. The extent to which they are given may seem excessive, but it must prove a powerful incentive and assistance to talent.

8. It has been remarked that there is comparatively little practical teaching in the School of Application for Artillery and Engineers at Metz. But a very extensive practical training is in fact supplied to these officers after they enter the service, remaining as they must do with the troops until promoted to the rank of second captain, and subsequently being employed in the arsenals, workshops, fortified places, &c.

9. The French have no "senior departments" for military education. In this respect their practice differs from that of England and Germany.

PART II.

MILITARY SYSTEM AND SCHOOLS IN PRUSSIA.

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MILITARY SYSTEM AND EDUCATION IN PRUSSIA.*

I. OUTLINE OF MILITARY SYSTEM.

ACCORDING to the law of the 3rd of September, 1814, which is the basis of the present military organization of Prussia, every Prussian above twenty years of age, is bound to service in arms for the defense of his country.

The military force of the country is made up of three distinct bodies, and the whole of the adult male population is distributed among them. It consists of,—

I. The Standing Army.

II. The National Militia or *Landwehr*, divided into two portions, viz., the first *Landwehr* and the second *Landwehr*.

III. The Last Reserve or *Landsturm*.

I. The standing army is composed of all young men between twenty and twenty-five years of age. The period of service in time of war is for five years, but in time of peace the young soldiers can obtain leave of absence after three years' service;—they belong for the remaining two years to what is termed the "reserve," receiving neither pay nor clothing, and they are subject to be recalled if war should break out.

Encouragement, indeed, is given and advantages held out to induce men to stay, and to take a new engagement for an additional term of six years; but it is said that only a small number are thus obtained. The bulk of the troops are men serving for this short time; and there are many, it should be added, whose term of service is even yet shorter. For all educated young men, all, that is, who pass a certain examination, are allowed, on condition that they pay for their own equipment and receive no pay, to shorten their service from three years to one. This privilege appears to be very largely used. It should also be stated, that young men of any class may volunteer to perform their service at any age after seventeen.

The Prussian standing army amounts at the present time to

* Compiled from the "Report, and Accompanying Documents of the Royal Commission on Foreign Military Education," 1857.

about 126,000 men. It is divided into nine army-corps or corps d'Armée, one of which is named the guard, and the others are numbered from I. to VIII. In each there is a regiment of artillery and a division of engineers. A regiment of artillery consists, in time of peace, of three divisions; each division of one troop of horse artillery and four companies, of which, one is Fortress artillery with two-horsed pieces. Each regiment has thus three companies for the service of the fortress and twelve for field service. The whole of the artillery is under the command of a general inspector, and it is divided into four inspections. An engineer division is composed of two companies. There are nine engineer divisions, one in each army corps. The whole are commanded by a general inspector, and they are divided into three inspections.

The promotion in the Prussian infantry and cavalry is regimental, and by seniority, up to the rank of major; after that it is by selection; and an officer who has been passed over two or three times may consider that he has received an intimation to retire from the service. In the artillery the promotion is by regiments; in the engineers it is general.

II. The first Landwehr, or Landwehr of the *first* summons (*des ersten aufgebots,*) consists principally of young men between twenty-five and thirty-two years of age, who enter when they have completed their period of service in the standing army. They are called out once every year for service with the divisions of the standing army to which they are attached, for a period varying from a fortnight to a month; and they may be sent in time of war on foreign service.

Those who have passed through the first Landwehr, enter at the age of thirty-two in the second Landwehr, or Landwehr of the *second* summons (*des zweiten aufgebots.*) They are called out only for a very brief service once a year, and they can not at any time be ordered out of the country, but continue to form a part of the *second* Landwehr until they are thirty nine years of age.

III. After the age of thirty-nine a Prussian subject belongs to the last reserve or Landsturm, and can only be summoned to service in arms upon a general raising, so to say, of the whole population, when the country is actually invaded by the enemy.

With the standing army, the center of the system, all the other forces are kept in close connection. For every regiment of the standing army there is a corresponding regiment of Landwehr, and the two together form one brigade. In the local distribution, every village and hamlet of the Prussian dominions belongs to a certain

regiment of Landwehr, serving with a certain regiment of the army, and belonging accordingly to one of the nine army corps.

Such is the military organization, which, from the important part played in it by the *Landwehr*, is sometimes termed the Prussian *Landwehr* system. The history of its formation is remarkable, and the circumstances which led to its creation helped also to create the very peculiar education of the army.

The Prussian *Landwehr* or militia is not of modern origin; in its form at least it is but a revival of the old feudal military organization, so far as that consisted of raising the country *en masse*, instead of keeping up a permanent, trained, and limited military force. *Landwehr* or *Landsturm** was the old German name for this feudal array, before the system of standing armies was begun in Europe by Charles VII. of France, with his Scotch regiments. It was possibly the failure of the trained Prussian armies—long reputed the models of military discipline—in the attack upon France in 1792, and still more signally at Auerstadt and Jena, which partly led to the revival of the *Landwehr* as the peculiar national force of Prussia. The means by which Stein, and after his expulsion, Scharnhorst, called it into activity, was a master stroke of policy under the existing difficulties of the country. The following outline may be sufficient to explain its effects upon education.

The condition which Napoleon had exacted at Tilsit—a reduction of the standing army from 200,000 to 40,000 men—would have lowered Prussia at once to the rank of a second-rate power. It was adroitly evaded by the plan of keeping only 40,000 men in arms at one and the same time, disbanding these as soon as they were disciplined, and replacing them constantly by fresh bodies. Thus the whole population of the country was ready to rise in 1813, after the crisis of Napoleon's retreat from Russia. The plan was chiefly due to the genius of Scharnhorst, whose early death deprived Prussia of her greatest scientific soldier. The *Landwehr* then proved itself a most efficient force, though its success was promoted by the national enthusiasm, which must prevent our taking such a period as a criterion of its permanent military working. Since that time it has continued to be the national army of the country.

We were assured that this peculiarity of the Prussian army system, by which almost every man in the country serves in his turn in the ranks, has had a tendency to improve the education of the officers. It seems to have been felt that the officers would not retain the respect of intelligent privates unless they kept ahead of

* Thus *Landsturm* is the word used for the rising en masse of the Tyrol in 1809.

them in education. And this impression appears to have been the cause of the royal edicts passed in 1816, by which it was required that every Prussian officer should pass two examinations before receiving his commission, one to test his general education, and the other his professional knowledge.

II. HISTORICAL VIEW OF PRUSSIAN MILITARY EDUCATION.*

The Prussian system of military education stands in close connection with the general education of the country, just as the Prussian military organization is the peculiar creation of that country's history. And the greatest improvements in the army and in its scientific teaching have been made at those remarkable periods when we should most naturally have looked for them—the time of Frederick the Great and the Liberation war of 1813—1814.

The leading principles of Prussian military education consist, *first*, in requiring from every officer in the army proof of a fair *general* education before his entrance, and of a fair *military* education afterwards. *Secondly*, they encourage a higher military education in a senior school, which has almost exclusively the privilege of supplying the staff.

In this requirement of a fair education, both general and military, *universally* from its officers, Prussia stands alone among the great military nations of Europe, and this honorable distinction is in a great measure the result of the diffused system of education throughout the country, and of the plan adopted by Stein and Scharnhorst, to make the officers the leaders of the army both in education and in military science.

The military schools of Germany may be said to have begun with the Reformation wars. Some such were founded by Maurice of Saxony, the great political and military genius of Germany in that century; the example was soon imitated in Baden, Silesia, and Brunswick, and a curious sketch of military education, by the hand of Duke Albert of Brandenburg, has been lately published from the Berlin archives, in which theology and mathematics hold the two most important places.

The first school of any real importance was founded in Colberg, by the great elector, Frederick William, in 1653. This had considerable success, and both his successors, King Frederick and Frederick William I., improved it greatly, and finally transferred it to Berlin. It was the time (about 1705, 1706,) of the great advance in military engineering under Vauban and Cochorn, and a school

* The chief authority for this paper is a very detailed account of the Staff School, (*Kriegs-Schule,*) by Friedländer, pp. 1—360.

for engineering was founded, in which some of their pupils had a great share. The first Prussian trigonometrical survey also dates as early as 1702; that of England was not begun till 1784. It may indeed be said that the scientific arms began to take a more favorable place in the Prussian army about this time. They have held, and even still hold in some respects, a less distinguished position in Germany than in France, England, or Sardinia; and the first instance of an artilleryman being made a general, was in the reign of Frederick William I.

On Frederick the Great's accession he found several military schools in existence. These had been chiefly founded by his eccentric father, who had a passion for Cadet Houses and cadets, and their object is said to have been to supply an education to the nobility, who at that time were very ill-taught in Germany. After Frederick's first wars, his own attention was much occupied by the need of a better military education, and he continued to work at the subject very zealously till his death. His example on this point, as that of a great military authority, is most instructive, since his object was at first only to educate cadets *before* their entrance to the army, but was afterwards extended to completing the education of officers already on active service. His views on the last point were carried out by Scharnhorst. They were the germ of the present Prussian military education.

It is curious to observe that the Austrian Succession War and the Seven Years' War, the first great wars since Louis XIV., and which broke the Thirty Years' Peace of the eighteenth century, are periods at which scientific military education made a great step in Europe. A Treatise of Marshal Count Beausobre's on the subject first showed the existing want; it is entitled "*Utilité d'une Ecole et d'une Académie Militaire, avec des Notes, ou l'on traite des Ecoles Militaires de l'Antiquité.*" It attracted great attention on its appearance. Most of the military academies properly so called, date from about this time. The earliest warrant for Woolwich, dates in 1741. The Theresianum of Maria Theresa was begun at Vienna about 1748. The first French school was the celebrated engineer school of Mezières founded in 1749. This was soon followed by the old military school of Paris in 1751, and by the school for artillery at La Fère in 1756. Frederick's own *Ritter Academie* dates from 1764.

Frederick began this institution with his usual energy, immediately on the close of the Seven Years' War. "My fire is quenched," he writes, "and I am now only busied in improving the practice of

my men. * * * * The position of the common soldier may be left as it was before the war began, but the position of the officers is a point to which I am devoting my utmost care. In order in future to quicken their attention whilst on service, and to form their judgment, I have ordered them to receive instruction in the art of war, and they will be obliged to give reasons for all they do. Such a plan, as you will see, my dear friend, will not answer with every one; still out of the whole body we shall certainly form some men and officers, who will not merely have their patent as generals to show, (*die nicht blos patentirte Generale vorstellen,*) but some capacity for the office as well." He had, in fact, seen with great admiration the improved military school recently founded by Maria Theresa; and as it is best on such points to let this great authority be heard for himself, we shall quote his own words:—

"In order to neglect nothing bearing on the state of the army, the Empress founded near Vienna, (at Wiener Neustadt,) a college where young nobles were instructed in the whole art of war. She drew to it distinguished professors of geometry, fortification, geography, and history, who formed there able pupils, and made it a complete nursery for the army. By means of her care, the military service attained in that country a degree of perfection which it had never reached under the Emperors of the House of Austria; and a woman thus carried out designs worthy of a great man."

His letters show that he contemplated an improved school, and he says to D'Alembert: "I send you the rules of my academy. As the plan is new, I beg you to give me your honest opinion of it." Accordingly, the academy was founded. We will describe it in his own words:—

"An academy was founded at the same time, in which were placed those of the cadets who showed most genius. The king himself drew up the rules for its form, and gave it a plan of instruction, which stated the objects of the studies of the pupils, and of the education they were to receive. Professors were chosen from the ablest men who could be found in Europe, and fifteen young gentlemen were educated under the eyes of five instructors. Their whole education tended to form their judgment. The academy was successful, and supplied able pupils, who received appointments in the army."*

This school, which was opened in 1765, was Frederick's only foundation of the kind; he was occupied with it incessantly. The plan of its studies was drawn up by his own hand, and we have

* "Histoire de mon Temps."—*Œuvres*, vi., p. 99.

many of his letters of encouragement to its pupils or professors. Whether he is writing to Voltaire, Condorcet, or "My Lord Marischal" Keith, he constantly shows both his well-known attention to the economy of his new school, and a paternal interest in his young cadets and their teachers.*

Accordingly, both in professors and pupils, the new institution soon gained an European character. Out of its twenty-first directors, no less than ten were distinguished foreigners; one of the best teachers at Berlin was D'Antoni, a distinguished soldier from the Turin institution and the artillery school at Alessandria—schools which were still the representatives of the military science of the great Italian generals, of the Duke of Parma, of Spinola, and Montecuculi.

This institution was still, as it would appear, upon the old principle of juvenile army schools, nor does Frederick seem to have set on foot any school for officers after entering the service. But he evidently felt strongly the need of improving his staff officers, and of raising the science of his artillery and engineers. Thus we find him referring to the French engineer school at Mezières; and he endeavored to raise the intelligence and education of his officers. It may, however, be suspected that the spirit of the "Potsdamer Côterie," as it was called, became gradually, and particularly after Frederick's death, too literary and speculative to suit the rough work of war; and it may, perhaps, be thought that some defect of this kind is still traceable in the excessive amount of teaching and the abstract nature of some of the subjects taught in the staff school at Berlin.

Such seems to have been the opinion of Scharnhorst, the virtual author of the present system of army education, and whom the Prussians still regard as their first authority on that subject. "Instruction is given," he says, "at the military school in all literature, in philosophy, and in many various sciences. Frederick seems to have wished to lay in it the foundation of the education at once of an officer and of a learned man. Few men, however, are able to excel at once in various branches of human knowledge, and the surest means to do so in *one* is not to attempt it in *many*."

* He gives himself, in his forcible style, the reasons for his attention to early military schools. He had found his young nobility excessively averse to such education. "They shrink from the army," he said, "because in this country it is a real training for the character. Nothing is passed over in a young officer; he is obliged to maintain a prudent, regular, and sensible conduct. . . . . This is precisely what they dislike, and one still hears the absurd and insolent expression, 'If my boy will not work, he will do none the worse for a soldier.' Yes, he may do for a mere man-at-arms (*fantassin*,) but not for an officer fit to be advanced to the highest commands, the only end of a good soldier's life, and which requires a really extensive knowledge."—*Œuvres*, ix., 117, 120.

We have referred to Frederick and his school rather to show the interest he felt in military education, than because his institution was very important. Military education was still very imperfect, and it completely languished in Prussia till Scharnhorst established it on its present footing.

Scharnhorst was himself an Hanoverian, but entered the Prussian service, and had seen by experience the defects of their system in the campaigns of 1792, 1793, and 1805. He had long devoted especial attention to military education and to all the scientific part of his profession. Along with Blucher and Gneisenau, he was considered one of the first generals of the army, and, on the exhaustion of Prussia after Jena, he was selected to remodel its whole system. He did not live to complete his work, having been killed early in 1812; but his statue near the bridge at Berlin, remarkable for its noble and thoughtful expression, records the gratitude of Prussia to its greatest scientific soldier.

"The perfection of the French military organisation," says Mr. Alison, appeared to him in painful contrast beside the numerous defects of that over which he presided. * * * * Boldly applying to the military department the admirable principles by which Stein had secured the affections of the burgher classes, he threw open to the whole of the citizens the higher grades of the army, from which they had been hitherto excluded. * * * * And every department of the public service underwent his searching eye."

The work began with the commission of 1807, of which both Stein and Scharnhorst were members. And the regulation of 1808 laid down the principle broadly, that the only claim to an officer's commission must be, "in time of peace, knowledge and education; in war, courage and conduct."

On these principles, during the next three years, Scharnhorst laid the foundations of the present education. He abolished most of the existing juvenile schools, with the exception only of the Cadet Houses, intended almost solely for the sons of officers. He changed the previous war school into a sort of school *d'Elite*, consisting of a senior and junior department, in which the younger soldiers of all arms were to be imbued with such knowledge as might give them a scientific interest in their profession, and in which senior officers (also of all arms) were to have a higher course of a similar nature, success in which was to form a recommendation for employment on the staff. He began the plan of the division schools, where all candidates for commissions, but not yet officers, might conduct their

military studies along with the practice of their profession. Its idea was to make some military study *necessary*, and successful study *honorable*, in the army. Finally, he began the present system of careful examination on entering the army.

The following historical notice of the origin and successive changes of the division schools is taken from a communication by Col. Von Holleben, and a member of the General Inspection of Military Instruction to the English Commission.

The cabinet order of the 6th of August, 1808, laid the foundation of the present system of military education. It regulates the appointment of Swordknot ensigns and the selection of officers, and declares that the only title to an officer's commission in time of peace shall be professional knowledge and education, and in time of war distinguished valor and ability.

The cabinet order of the 6th of August, 1808, could only come gradually into operation; the system of military examinations had to be created, and the educational institutions had to receive a new organization, under the superintendence of a general officer. Four provincial boards of examination were successively established, and on the 1st December, 1809, a body of instructions, still very vague and general, was issued for their guidance.

A cabinet order of the 3rd of May, 1810, remodeled the military schools, directing, in addition to the cadet schools at Berlin and Stolpe, the formation of three military schools for Swordknot ensigns, (*Portepée-Fähnriche*,) one at Berlin for the marches (*Die Marken*,) and Pomerania, a second at Königsberg, for east and west Prussia, and a third at Breslau, for Silesia; and the formation of a military school at Berlin for officers. All these institutions were placed under the general superintendence of Lieutenant-General Von Diericke, who had also the special superintendence of the boards of examination. A board of military studies was created and intrusted, under his control, with the task of carrying the regulations into effect.

Before, however, the new institutions attained to any stability the war years of 1813—14—15 intervened, and the operations of the board of examinations ceased.

Soon after the conclusion of peace directions were given that the examinations should recommence, with an equitable consideration of the claims of the Landwehr officers, ensigns, and other young persons who had grown up during the war.

At first there was only one board of examination at Berlin, with large discretionary powers as to their mode of procedure. In April,

1816, a cabinet order was issued to form boards of examination for the Swordknot at every brigade, as the present divisions were then called, besides the existing board at Berlin, for the examination for an officer's commission.

Contemporaneously with the nine boards of examination, the board of military studies, by an order of January, 1816, directed the establishment of schools for every brigade, and attempted to gradually regulate the instruction they gave. The schools contained two classes, the lower to prepare candidates for the Swordknot, the higher to prepare candidates for the rank of officer. As, however, no standard of attainment was required for admission into the schools, their instruction had to commence with the first elements, and was charged with more work than it could perform. The weaker scholars stayed two, three, or more years in the lower class, and the education of the better scholars was impeded.

During this and the following period the authority over the examination boards (the *Præsidium*,) was distinct from that over the schools, (the general inspection,) and it was not till later that both authorities were vested in a single person. This division of powers, intended to secure the independence and impartiality of the examinations, led to the result that the two authorities were occasionally led, from a difference of principles, to labor in different directions. Still, in the infancy of military education, the rivalry it occasioned was favorable to a rapidity of development.

An order of the 16th of March, 1827, added French to the studies for the ensigns' examination, and fixed a higher standard of attainments in military sciences for the officers' examination.

Nearly at the same time, a cabinet order of the 27th of March, 1827, directed that there should be only one class for Swordknot ensigns in the division schools, and that after October, 1829, the candidate should obtain a testimonial of fitness for the rank of Swordknot ensign previous to admission as a student.

Accordingly young men had to be prepared for examination for the Swordknot at their entrance into their corps, or might prepare themselves by private studies and instruction during their service.

The task of the schools, still very comprehensive embracing all the liberal sciences as well as the military, was accomplished during this period in two courses of nine months, in a higher and a lower class.

A cabinet order of the 31st of January, 1837, introduced the entrance examination, instead of the examination for the Swordknot.

it being declared that every candidate for the commission of an officer, after his reception into a corps, should prove in an examination his possession of the knowledge requisite for a Swordknot ensigncy before his actual appointment. At the same time a regulation of the ministry of war, of the 17th of December 1836, remodeled and more precisely defined both the entrance (Swordknot ensign) examination, and that for the commission of an officer. This regulation, while it essentially modified the instruction given at the division schools, furnished them at the same time with a more certain clue for their guidance. The preparation of youths for the Swordknot examination during their service in the corps was discontinued. But the standard of the entrance examination was still too low, requiring only a small portion of the branches of a general liberal education, and that not in the shape in which they are taught in our gymnasia. Hence the evil result, that young men, previous to their entrance into a corps, had usually to prepare for the military profession at private institutions instead of at the gymnasia, and nevertheless brought with them a very defective amount of preparatory training; on the other hand, the demands of the officers' examination were very multifarious. It still required the general scholastic sciences by way of formal education, and the military sciences as a special education for the military profession. Thus the task of the division schools continued overwhelming, and an aim was set before them which they could not attain.

A regulation of the 4th of February, 1844, reformed simultaneously the whole system of military examination and education.

The views which guided these reforms, the improvements and advantages which were hoped to be thereby obtained, were, in general, the following:—

1. The military profession, like every other, requires a general school education intended generally to cultivate the mind, distinct from the subsequent special and professional education for which the former is the necessary groundwork.

The former is tested in the examination for the Swordknot, the latter in the officers' examination.

2. The preparatory education required from the candidate for a Swordknot is the function of the ordinary schools of the country. Nothing but what they can impart is required, and from consideration of the youthful age of the candidates (seventeen years,) the amount of preparatory training required is not the attainment of the highest class of the gymnasium, but only that required for admission into the Prima.

3. The required previous training not only gives the candidate a more certain basis for his subsequent military education, but, as being the groundwork of all professions, leaves him afterwards at liberty to cultivate the special knowledge requisite for any profession that he may prefer.

4. The division schools are freed from a multifarious course of instruction in the scholastic sciences, a task beyond their power; the result of which was that the majority of scholars were very little advanced in formal and general education, and but superficially grounded in the elements of the professional sciences, while they spent years in being drilled for an examination, instead of being educated for life.

5. If the division schools have an able staff of military teachers, they can give a good professional education. The younger officers, even if they never received the full training of the gymnasium, may still, by their professional training, raise themselves above their subordinates, (a class in Prussia often highly educated,) and are started with an excellent preparation for their professional career.

6. By the amount of liberal education required in the examination for the Swordknot, the friends of those destined for the military profession are admonished to provide them an education equal to that received by the members of other professions.

7. By the method pursued in the examinations the power is retained of raising or lowering the standard according to circumstances. When the supply of officers is deficient, the standard can be lowered; at other times, as at present, it may be raised. Since the above-mentioned regulations, the following essential alterations have been introduced:—

1. The examination for the Swordknot is again placed after admission into the corps, but no one can be admitted to attend the division schools without a testimonial of fitness for the rank of Swordknot ensign.

2. A testimonial of fitness for the university, *i. e.*, to have passed the abiturient examination, dispenses with the examination for the Swordknot. In consequence of this rule fifty abiturients on an average annually enter the army. These, as well as the selectaner of the cadet corps, must be considered, in point of scientific education, an excellent supply of officers. From the powerful impulse that military instruction has received in the last fifty years, it may be expected that the time is not distant when the candidate for an officer's commission, instead of passing the Swordknot examination,

will have to bring the finished training of the gymnasium; in other words, to have passed the abiturient examination.

3. Instead of the seventeen division schools there are now by the regulation of 1844, only nine, and a further reduction of their number to four or three is contemplated, with an improvement of the staff of teachers and a stricter supervision of the scholars.

III. SYSTEM OF MILITARY EDUCATION AND PROMOTION.

The standing army composed in the manner and under the circumstances already described, is supplied with officers who must have a good general education, and have served in the ranks, or have obtained a certain amount of professional instruction. The usual course is as follows:—

Young men obtain a nomination from the colonel of a regiment. This nomination admits them merely to service in the regiment as privates, with a recognition of their being candidates, *aspiranten* or aspirants, for the rank of officer. Before they obtain that rank, the following conditions must be fulfilled. They must pass an examination in the common subjects of a good general education, such as the sons of well-born or wealthy civilians may be supposed to receive. They must serve six or nine months with the troops; they must attend nine months at a division school, or twelve months in the artillery and engineer school, where they receive a course of special military instruction; and they must pass an examination in professional subjects before a board sitting at Berlin. They are then eligible for a vacancy. In order to obtain a commission they require further the recommendation of the officers of the regiment.

It is obvious to remark, that in obtaining a commission in the Prussian service the candidate's chance depends greatly on the recommendation of the colonel and the after assent of the officers. The effect of this is to maintain an exclusive character in the army. Above two-thirds of the commissions are obtained by the course described above; the remainder are granted to those who pass through the cadet schools.

Of these there are five altogether, four junior establishments, situated in certain provincial towns, and one senior or upper school at Berlin, to which the others are merely preparatory. They are all supported by the state; mainly for the purpose of educating the children of meritorious officers in want of assistance; but they are also open to others. With the exception of the highest class of the upper school, the *Selecta* above mentioned, the instruction given is of a perfectly general character, and there is no obligation even for

those who have received the most ample pecuniary assistance to enter the military profession. The discipline, however, is military, the teachers are mostly officers, the pupils are regularly drilled, and most of them actually go into the army. This they do in ordinary cases without going through the highest or select class in which professional instruction is given; they merely pass the same preliminary examination as the candidates nominated by the colonels of regiments; they enter the army without their commissions, and have to obtain them in the same manner as the other candidates, by serving six or nine months with the troops, and by following their professional studies in the division or artillery and engineer schools, and by passing the officers' or second examination before the examining board at Berlin. Those who do remain to go through the highest or select class receive their professional instruction in it instead of in the division or artillery and engineer schools, and they are examined for their commissions by the board while still at the cadet school.

Thus, in the course usually followed, three requisites are exacted in Prussia before a commission is given; first, a good general education; secondly, some actual military service; and, thirdly, professional knowledge gained by something like a year of military study. But the military service is not required from the upper thirty students of the *Selecta* of the Cadet House.

It will be well to mention, at the commencement, the names of the two examinations. The first, the preliminary examination, merely testing the general education, admits to a particular grade among non-commissioned officers; those holding it rank between sergeants and corporals, and in consideration of their being candidates (*aspiranten*) for a commission wear a different sword-knot, and hence have the name of Swordknot ensign or *Portepée-fähnrich*. The first or preliminary examination is accordingly called the *Portepée-fähnrich* examination. The second, the professional one, is the officers' examination, for the commission of second lieutentant.

These two examinations, for the grade of *Portepée-fähnrich* and for the officer's commission, are either conducted or controlled by the Supreme Military examinations Board, (*Ober-Militair-Examinations-Commission*) in Berlin, a body partly composed of military officers, partly of eminent civilians.

The various examining boards, the central and the local ones, which conduct these two examinations, are quite independent of the military schools, and were formerly presided over by a different

head; but in order that the system should be uniformly carried out, and as Colonel von Holleben expresses it, that "*the examinations should exercise a salutary influence on education, and that their standard should be adjusted to the capacities of the schools*," they have now been placed under the same control as the military schools.

The whole department of military education is therefore now under the control of a single high functionary, bearing the title of the general inspector of the military schools, military education, and military studies (*das Militair Erziehungs-und-Bildungswesen*,) who reports direct to the king on all subjects relating to examination and instruction. He submits his proposals on matters of administration to the minister of war, who issues the necessary orders to the boards charged with the financial control of the various schools.

The general inspector is assisted by a supreme council or board of military studies, composed of field officers of the general staff and of the special arms, the directors of the war school, of the supreme board of military examinations, of the artillery and engineers school, the commander of the cadet corps, some of the consultative assessors (*Vortragenden Räthen*,) of the minister of worship, and of individuals selected from the general body of learned men (professors.)

The principal military schools of Prussia may be divided into five classes:—

I. Those which give a good general education to the sons of meritorious officers, but which are open to others, such as—

1. The Cadet Houses or Cadet Schools (*Cadetten-Häuser*,) which supply a certain amount of instruction in military professional subjects.

II. Such as supply professional instruction to young men who are candidates for the rank of officer in the Prussian army. These are—

2. The Division Schools (*Divisions-Schule*,) nine in number, one for each army corps.

3. The artillery and engineers schools in Berlin.

III. Those which afford professional instruction to officers already in the service, to qualify them for special duty, limited to—

4. The War School or Staff School (*Kriegs-Schule*,) in Berlin.

IV. Those intended to give special instruction for the training of non-commissioned officers and men. Such as—

5. The School Division or Non-commissioned Officers School (*Schulabtheilung,*) at Potsdam.

6. The Regimental Schools (*Regiments und Bataillons Schulen.*)

7. The Music and the Swimming Schools, and the Central Gymnastic School in Berlin (*Central Turn-Anstalt.*)

8. The Veterinary School (*Thierarzeneischule.*)

V. Those intended to give gratuitous education to the children, boys and girls, of non-commissioned officers and soldiers, whose parents are too poor to provide for them. Such are,—

9. The Military Orphan Houses (*Militair-Waisenhäuser,*) at Annaburg, Potsdam, and Pretzsch.

10. The schools for soldiers' children.

In addition to these might be mentioned the Medical Institution, particularly the Frederick-William's Institution at Berlin, and the Knight Academy (*Ritter-Academie,*) or Noble School, in Liegnitz.

The annual cost to the state of the military schools in 1856, appears to be as follows:—

NAME.	Salaries. Dollars.*	Other Expenses. Dollars.*	Total Dollars.*	Number of Students.
Department of General Inspector,.....	5,872	250	5,922	.....
Supreme Military Examinations Board,.....	5,400	300	5,700	.....
Board of Military Studies,.....	848	.....	848	.....
Board of Examiners for Artillery Lieutenants,	.....	60	60	.....
Cadet House at Berlin,.....	12,944	.....	12,944	420
" " Potsdam,.....	15,805	24,285	40,090	200
" " Culm,.....	15,738	18,436	34,174	160
" " Wahlstatt,.....	16,253	22,706	38,959	200
" " Bensberg.....	15,935	24,853	40,788	200
General War or Staff School,.....	18,559	3,013	21,565	120
United Artillery and Engineers School,.....	15,025	1,910	16,935	240
Veterinary School,.....	8,514	4,165	12,679	.....
Gymnastic School,.....	4,046	720	4,766	.....
Division Schools,.....	10,800	6,195	16,995	Variable.
" Libraries,.....	400	1,200	1,600	.....
Miscellaneous,.....	.....	680	680	.....
Totals,.....	146,132	108,777	254,909	

Or about £38,236 annually, exclusive of the charge for buildings and repairs, and the original outlay for their first establishment. The pay of the student officers, and the pay and allowances of the military professors and teachers, are, however, drawn from their corps, so that the above-mentioned seems only to include the extra pay granted to the professors, &c.

The expenses of the Non-commissioned Officers School, of the military orphan houses, and of the schools for soldiers' children, are not given in the printed paper from which these details have been extracted.

* A Prussian dollar is equal to three shillings of English money, and 70 cents of United States currency.

IV. EXAMINATIONS—GENERAL AND PROFESSIONAL—FOR A COMMISSION.

Two examinations, one in general and the other in professional knowledge are required of all candidates for a commission upon or soon after their entrance into the army, unless they can bring a certificate of having successfully completed the regular course of a gymnasium, in which case they are excused from the first.

These two examinations, through which alone admission is obtained to the rank of officer, are so important, and hold so prominent a position in the Prussian military system, that we propose to preface our account of the nature and extent of each of these examinations by a short tabular statement of the circumstances under which the candidates for each arm of the service respectively pass them.

The following Candidates offer themselves,	for the Preliminary, Ensign's, or *Portepée-fähnrich* Examination,	for the Second or Officer's Examination (in all cases before the Supreme Board at Berlin.)
Those presented by the Colonels of Regiments,	Before, after, or during (usually before) six months' service with the Troops, before the local Division Board;	After nine months' military instruction in the Division School.
Those coming at the usual time from the Cadet House (from the class called *Prima*,)	On quitting the Cadet House, before the Supreme Board at Berlin;	After six months' service with the Troops, and nine months' military instruction in the Division School.
Those who stay an extra year in the Special or Select class (*Selecta*) of the Cadet House,	Before admission to the Special or Select class (*Selecta*,) before the Supreme Board at Berlin;	On quitting the Cadet House, after one year's military instruction in the Select class *Selecta*.
Those for the Artillery or Engineers, except when they came from the Special or Select class, (*Selecta*,) of the Cadet House,	After nine months' service with the Troops, and three months' stay at the Artillery and Engineers School, before the Supreme Board at Berlin;	After one year's stay at the Artillery and Engineers School.

1. *The Preliminary or Ensign's (Portepée-fähnrich) Examination.*

According to a special law, any young man above seventeen and a half and under twenty-three years of age, whether he be a private or a corporal, if he has served six months in the army, and can obtain from the officers of his company a certificate of good conduct, attention, and knowledge of his profession, may claim to be ex-

amined for the grade of ensign or (*Portepée-fähnrich.*) If he succeed in this examination, he is recognized as a candidate, an *aspirant* for a commission; but his prospect of obtaining a commission is subject to a variety of subsequent conditions.

In practice, a young man who aspires to a commission applies to the colonel of the regiment and usually obtains a nomination before he actually joins; and, as the examination is entirely of a civil character, he is usually glad to try and pass it at once. Having recently come from school, he feels probably better prepared than he is likely to be at any subsequent time: for on joining the corps, he will have for some time to conform to the life of a private soldier, to sleep and mess with the men, and to mount guard in his turn; and with the drill and exercises, and the marching and manœuvring with the troops, he will have enough to occupy him to prevent his preparing for the examination. The two qualifications for the ensign's grade are, the test of the examination and the six months' service; but it appears to be indifferent in what order they are taken, whether service comes first and examination after, or *vice versâ*.

The examinations take place quarterly, at the beginning of every January, April, July, and October. They are held in the great garrison towns by local military boards, consisting of a president and five examiners. Applications for permission to be examined must be made at least a fortnight before, and must be accompanied by certificates stating the candidate's birth, parentage, &c.; certificates of diligence and good conduct from the schoolmasters or other teachers who have instructed him; and of bodily fitness from an army surgeon.

The local board of examiners is appointed by the general officer in command of the army corps, the centers of examination corresponding in present practice with the localities assigned to the division or army-corps schools, nine in number, presently to be described.

The first part of the examination is on paper; a *vivâ voce* examination follows.

On paper the young men have to write three themes or compositions in German, to translate two passages, one from Livy or Sallust, another from Cæsar's Commentaries, Cicero's Epistles, or Quintus Curtius; to translate sixteen or twenty lines from French into German, and two passages, a longer and a shorter, from German into French. They have one question in common arithmetic, one in equations, progressions, or logarithms; one in geometry, one in

trigonometry; they have one in mathematical or physical geography, one in the general geography of Europe and its colonies, and one in that of Germany and Prussia. There is one question in Greek or Roman history; one in the earlier German history; one in modern; and one in Prussian history. They have also to show that they are acquainted with the common conventional signs used in representing the surface of the earth in maps; and they have to copy a small map of a group of hills.

The time allowed for each question is about three quarters of an hour or an hour; for each German theme, it is as much as an hour and a half or two hours.

The questions are of a comprehensive character; *e. g.* Give a history of the campaign of 1813, or of the life of Alexander the Great; enumerate the rivers flowing into the Mediterranean Sea, with the principal towns situated upon each of them. The German themes are, first, a *curriculum vitæ*, an account of the candidate's life, which is, however, not supposed to count in the result, and is merely for the examiner's information; second and third, two themes on some sentence or proverb, for the first of which the examiner assists the candidate by *vivâ voce* questions and corrections in drawing up the preliminary outline of arrangement; for the second he is left entirely to himself.

There is a subsequent *vivâ voce* examination in all the subjects, drawing excepted. The candidates are taken in small classes, not exceeding seven in number, and are examined together, but not in public.

The results of the examination are considered according to the system of *predicates* or epithets, sometimes also called *censures*. The candidates' answers are characterized as excellent (*vorzüglich*,) good (*gut*,) satisfactory (*befriedigend*,) insufficient (*nicht hinreichend*,) or unsatisfactory (*ungenügend*. Numerical values are attached to each of these epithets; "excellent" is marked with 9; "unsatisfactory" counts as 1; and according to the amount of importance attached to the different subjects the marks thus given are multiplied by a higher or lower number, by 5 in one case, by 3 or by 1 in others. German, Latin, and mathematics have all the highest estimate of 5, and are each five times more important than drawing, which is marked by 1; geography, history, and French, are each valued at 3. A young man who gets the *predicate* "excellent," in German, will receive 45 marks, his 9 being multiplied by 5; whereas the same predicate for history would obtain him only 15, and in drawing only 5 marks.

German,	5	Total, 25.
Latin,	5	
Mathematics,	5	
History,	3	
Geography,	3	
French,	3	
Drawing,	1	

A report is then drawn up, and according to the marks or predicates, the candidates are pronounced as admissible with distinction, admissible with honor, or simply admissible; or their re-examination after six months, their re-examination after a year, or their absolute rejection, is recommended.

This report, with the candidates' certificates, is forwarded to the supreme military examinations board at Berlin, and, if approved by them, is submitted in their quarterly report to the king; and the result, when sanctioned by him, is communicated to the respective corps.

The candidates are all informed not only of the practical result, but also of the particulars of their examinations; they are told in what subjects they have failed, and in what they have succeeded. The candidates can not, under any circumstances, try more than three times.

The young men who pass, are thus, so far as their qualification in point of knowledge is concerned, pronounced admissible to the ensign's grade. They have of course to complete their six months' service with the troops. Yet even when this is completed, a vacancy in the list of ensigns must be waited for, and months may pass before the aspirant receives the distinctive badge, the special Sword-knot, which marks his superiority to the corporals, and shows that he has gained the first step that leads to a commission.

The examination that has now been described is obviously one for which preparation may be made in the common public schools, and under the usual civilian teachers. A young man of seventeen need not have been positively destined to the military profession, nor have gone through special preparation for any length of time beforehand. The boards of local military examiners are content to take them as they are offered, inquiry only being made as to their birth and connections, and their previous behavior at school or under tuition.

In fact, those who have passed successfully through the full course of a school which prepares for the universities (a gymnasium,) are excused the ensign's examination. The certificate they have received on going away from school, upon the *abiturient's* or leaving examination, as it is called, is considered quite sufficient; except in

the case of candidates for the artillery or engineers, who are expected to show greater proficiency in mathematics; and certainly a boy in the head class of a gymnasium ought to be able to pass the preliminary examination with perfect ease and with credit. The amount of knowledge required and the particular subjects selected are not those of the first, and are scarcely those of the second class of a gymnasium; and the assertion was even made that a boy from the upper third class might very well hope to pass for an ensigncy. Possibly a little extra tuition from the preparatory establishments, which are said to have sprung up with the special function of "fabricating Fähnrichs" might in this instance be required.

The official programme is here given, and may be compared with the studies prescribed in the upper classes of the Cadet House at Berlin, (*see* the account of that school.)

1. In their own language, good legible handwriting, a correct style, free from orthographical or grammatical mistakes, facility of expression in writing and speaking; some evidence of a knowledge of German literature.

2. In Latin, facility in understanding the Latin prose writers ordinarily read in the second class of a Prussian gymnasium. A written exercise in translation from Latin into German; grammatical analysis of some passages.

3. In French, facility in reading and in translating from German into French, and French into German, grammatical analysis of French sentences, and a knowledge of syntax.

4. Mathematics:—

(*a.*) Arithmetic and Algebra;—familiarity with the ordinary rules for the extraction of the square root of whole numbers and of fractions; Proportion and its applications including questions in Partnership and Compound Proportion; the theory of powers and roots, with integral and fractional, positive and negative exponents. Equations of the two first degrees, with one or more unknown quantities; Logarithms, Logarithmic Equations, Arithmetical and Geometrical Progression, and practice in the application of the various theories.

(*b.*) The complete elements of Plane Geometry, measuration of rectilineal figures and of the circle, transformation and division of figures; the first elements of the application of Algebra to Geometry.

(*c.*) Plane Trigonometry, Trigonometrical functions and their Logarithms. Use of trigonometrical tables. Calculation of particular cases of triangles, regular polygons, and segments of circles.

In consideration of the especial importance of this discipline for officers of the artillery and engineers, a higher predicate (*i. e.* a greater number of marks) will be required in the exercises of candidates for these two services; the knowledge expected in their case will be, though not more extensive, more thorough and deep.

5. Geography:—The general principles of Mathematical and Physical Geography, knowledge of our planetary system, of the motions of the Earth, and of the phenomena immediately dependent upon them. Readiness in drawing from memory the outlines of the more important countries, with their principal mountains, rivers, and cities. General outlines of Political Geography, in the case of the mere states out of Europe; a detailed account of the elements of European statistics, more particularly in the case of Germany and Prussia.

6. History:—A knowledge of the more remarkable events in the history of great nations, of the general connection, causes, and consequences of these events; a knowledge of the remarkable men of all such nations down to the present time. Special knowledge of the history of Greece, Rome, Germany, Prussia, with particular reference in this last case to its external growth, inner

development, and to the principal events of the most important wars since the middle of the eighteenth century.

7. Readiness in general drawing, and in constructing mathematical figures; some skill in drawing plans of positions and mountains, in the way of preparation for military plan drawing.

8. The candidate may, in addition, be examined in other subjects, in which his certificates show that he has been instructed; for example, in Natural Philosophy, so far as included in his previous course of instruction.

It must be remembered that either before or after this examination some months must be spent in actual service with the troops by all but the pupils belonging to the *Selecta* of the cadet school; and that nine months of study at the division and artillery and engineer schools intervenes before the officers examination takes place.

2. *The Second or Officer's Examination.*

The second or final examination for a commission, which generally ensues when the work of the division school is over, is held in Berlin only, and is conducted immediately by the central commission, to which reference has so often been made—the supreme Military Examinations Board, the *Ober-Militair-Examinations Commission*. This board or commission, a list of the existing members of which is given in page 179, consists, for the purpose now in consideration, of a president and five examiners, selected from the larger number to examine candidates for commissions.

The examinations are held continually; two opportunities are afforded every year to the candidates sent from each of the various army corps. The requisite papers must be forwarded to the commission eight days at least beforehand, and the candidates must appear in Berlin, and take up their quarters in the buildings placed at the disposal of the board on the Friday preceding the day fixed for the examination. The examination usually begins on the following Monday, and lasts through the week. The expenses of the journey are allowed, except, perhaps, when the candidate comes up a second time.

The certificates to be presented are the following:—

1. The certificate of birth, age, parentage, &c. (This is called the *Nationale*.)

2. The *Curriculum Vitæ*, (an account of the circumstances of the candidates's past life, his education, employment, &c., &c.)

3. The certificate that he has already passed through a previous examination (the *Tentamen*,) held by the authorities of the division school.

4. A certificate of conduct during his stay at the division school.

5. A military drawing (*Croquis*,) with an attestation given by his instructor that it is the candidate's own doing.

This examination, like the preliminary one, is partly on paper and partly oral. General directions are given that the examiners in both cases shall look mainly to the question whether the candidate has sufficient positive knowledge of his subjects, and capacity to explain and express himself, that mere lapses of memory shall not be regarded, and that natural endowments shall be principally looked to.

In the written examination, the candidate has four questions given him in what is called the knowledge or theory of arms (*Waffenlehre*,) including under that term all kinds of ammunition; three in tactics; one question in the rules and regulations which touch the duty of a subaltern officer; two questions in permanent and two in field fortification; one exercise in surveying, to test his acqaintance with the common instruments, and one to try his knowledge of the principles of plan drawing (*Terrain-Darstellung*; while his general skill in military drawing is proved by his either copying a plan placed before him, or drawing one from a relief model of a mountainous district (*nach Bergmodellen*.)

There is a *vivâ voce* examination in all the subjects.

The commission meets once every month to consider the examinations held since their last meeting. The result is announced under the form of the *predicates* or epithets already more than once referred to. Honorable mention is accorded to an *excellent* examination, and mention to a *good* one. If there has been an unsatisfactory result in one of the subjects, the candidate may compensate for it by superiority in other subjects, but can only in this case be qualified as *satisfactory* (*befriedigend*,) and an adequate knowledge of "arms" and tactics is regarded as indispensable in candidates for the infantry or cavalry, and in "arms" and fortification in those for the artillery and engineers. No superior work in other subjects is allowed to make up for a deficiency in these.

If a candidate's work is marked as *insufficient* (*nicht hinreichend*,) he is sent back for another half-year, and if he has done *unsatisfactorily*, for a complete year of additional study, with leave to appear for re-examination after that interval. In a case of re-examination, the two last *predicates* (*nicht hinreichend* and *ungenügend*) entail final rejection.

The report of the board is submitted to the king; the results are communicated to the various corps. The announcements sent to the candidates state the predicates assigned to the various portions of

their work. Those who have passed, receive certificates of being qualified for the second lieutenant's commission:—

This rank, however, is not immediately granted. A vacancy may be long in occurring, and must be waited for. Promotion is given according to their seniority on the list of ensigns in the regiment. Another condition must also be satisfied. When a vacancy occurs, the senior ensign's name can not be submitted to the king for his appointment without a document stating on the part of the officers of the regiment that he has the requisite knowledge of the duties of the service, and that they consider him worthy of admission amongst them (*würdig in seine Mitte zu treten.*) If the majority is opposed to his admission, the name of the next ensign in order of seniority is, without further discussion, brought forward; if a minority or merely some individual officers take exception, they state the grounds of their opinion, which are then submitted for consideration.*

Special merit in the examination may be, at the king's pleasure, held a sufficient reason for promotion before all candidates examined at the same time.

The following is the programme of the studies, proficiency in which is expected of candidates at the second or officer's examination:—

I. KNOWLEDGE OF ARMS AND MUNITIONS.

A. *Of Gunpowder.*

1. General views on gunpowder and its application.
2. Ingredients of gunpowder; its qualities and use.
3. Fabrication of the same; principles on which the manufacturing process is based.
4. Statement of the various kinds of gunpowder in use, and their distinctive qualities.
5. Of the ignition, combustion, and power of gunpowder.
6. Qualities of good powder; examination of the same:
   - *a.* According to their external characteristics.
   - *b.* According to force developed.
     - *α.* By the mortar eprouvette.
     - *b.* By the smaller eprouvette.
     - *γ.* Or, in default of such instruments, by practical experiment.
7. Manner of preserving gunpowder; characteristics and treatment of damaged gunpowder.
8. Precautions to be taken in working with gunpowder, and transporting the same.
9. The most ignitible materials for percussion caps, and the like.

* This certificate, according to a statement received in conversation, is in the first instance from the officers of the company, to the effect that the ensign in question is well conducted and likely to be a desirable addition to their number; then from the major of the battalion, and from the colonel of the regiment.

B. *Of Artillery.*

1. Classification of guns, according to species, calibre, and the kind of warfare for which they are intended. (Field, siege, and standing artillery.)

2. General qualities to be required of a properly constructed piece of ordnance.

3. Construction of the piece; description of the same according to the various kinds of guns, specifying the use of the different parts. (An exact statement in figures is only called for in reference to the length, weight, and diameter of the piece.)

- *a.* Materials; qualities required of them; enumeration of the materials generally employed.
- *b.* Interior construction of the piece; length of bore, chamber, windage, and touchhole; their influence on the range.
- *c.* External construction of the piece; appliances for pointing and managing it, and connecting it with the gun-carriage.

4. Construction of the gun-carriages; enumeration of the different kinds of the same, according to the description of gun, its destination, and materials.

- *a.* Specification of the principal component parts of the carriages.
- *b.* Distinctive characteristics of the construction of the various denominations of carriages.
- *c.* General principles for determining the proper construction of the same.
- *d.* General notions relative to the proportion of the weight of the carriage to the piece.

5. Construction of the limbers.

- *a.* Enumeration of the different kinds of limbers.
- *b.* Principal component parts and distinctive characteristics of the construction of the various kinds of limbers.
- *c.* General notions relative to the weight of the limber in proportion to the piece and the gun-carriage.

6. Statement of the various descriptions of wagons used by the field artillery, and their destination.

7. Ammunition; enumeration and description of the objects belonging to it. (Exact statements in figures are only required for the diameter and weight of the principal kinds of projectiles.)

- *a.* Projectiles; statement of the species of projectiles used for the different kinds of guns, and their construction.
  - *α.* Round shot, cannon ball, grape.
  - *β.* Shells; their various species.
  - *γ.* Light balls.
  - *δ.* Stones.
- *b.* Charges; general description of them.
  - *α.* In field-pieces.
  - *β.* In heavy artillery.
- *c.* Primings; enumeration and description of the various kinds of primings.
- *d.* Other military fireworks; statement of the principal species, and their general construction.
- *e.* Transport of ammunition by limbers and carts; packing of the same.

8. Moving and working the guns:

- *a.* General notions on the working of field-pieces.
- *b.* Different kinds of operations with field-pieces; unlimbering and limbering up.
- *c.* Position of field-pieces in firing, with regard to effect, cover, and celerity of movement.
- *d.* Principal manipulations in working the same.
  - *α.* Loading.
  - *β.* Pointing.
  - *γ.* Discharging; the process according to the different kinds of projectiles.

e. Ascertaining the efficiency of a gun previous to using it.
f. Momentary unserviceability of guns.
g. Expedients for repairing a disabled carriage.

9. Artillery practice.
   a. Exposition of the theory of firing (as far as it can be elucidated by a knowledge of the elements of mathematics;) general notions concerning the curve of round and hollow shot, and the influence of the force of powder, of gravity, and of the air's resistance upon their velocity; the curve after the first grave; trajectory of grape shot.
   b. Classification and denomination of the various methods of firing or throwing projectiles.
   c. Range; conditions on which it depends; its practical limits.
   d. Effect of projectiles.
      α. Probable accuracy of practice; circumstances on which it depends.
      β. Force of the blow; circumstances on which it depends.
   e. Recoil, jumping, or bouncing; explanation of such occurrences.
   f. Application of the various descriptions of guns, projectiles, and methods of firing, according to the nature of the mark, the distance, the position of the adversary, and the ground.

C. *Of Small Arms.*

1. Classification and denomination of small arms.
2. General principles applied to the construction of the musket, the infantry and wall-piece rifle, the carbine, the cavalry rifle, the pistol, and the engineer musket (if the candidate is in the engineers.)
3. Description of their construction and arrangement in particular; enumeration of the separate parts (an exact statement of dimensions only required for the principal ones;) object and effect of the same.
4. Estimate of the practical utility of the various kinds of fire-arms as employed by one infantry and cavalry (no technical or theoretical investigation, but only practical remarks.)
5. Ammunition, as the ball, cartridge, and patch:
   a. Its preparation.
      α. In the usual manner.
      β. In cases of need, in default of the usual implements.
   b. Preserving, packing, and transporting it, both in carriages and by the soldier himself.
6. Management of small-arms:
   a. Theory of firing (in its general scientific bearings, *vide* artillery) as applied to small-arms; repeated elucidation of the curve, line of metal, axis produced, and the relative position of these three lines in the different ranges.
   b. Practical rules for loading, presenting, taking aim, and discharging, at different elevations of the adversary, and at different ranges.
7. Cleaning and preserving the arms.

D. *Of Side-Arms.*

1. Classification and denomination of the same:
   a. Cavalry side-arms.
   b. Lances.
2. Statement of the general principles on which their construction is based.
3. Examination of the state of side-arms on receiving them (within the limits mentioned above in C. 4.)
4. Effect and management of the same.

II. TACTICAL BRANCHES.

A. *Army Organization.*

1. General sketch of the organization of the Prussian army.
2. Characteristics of the different kinds of troops (arms;) their peculiarities

(their weapons are included under the former head,) their equipment and destination.

B. *Elementary Tactics.*

1. Account of the regulations concerning the distribution and formation of a battalion of infantry, a regiment of cavalry, and a battery, in line or column.
2. Formation of the different columns from the line, forming square, deploying and forming line, movement in advance, to the rear and to the flank, changing front and direction in line and column.
3. Formation of *tirailleurs* and skirmishers; posting, covering, moving, reinforcing, reducing, and relieving the same.
4. General rules on the conduct of the separate arms in action.
   a. Engagement of infantry under fire and hand to hand, in close and extended order, in attack and defense.
   b. Charge of cavalry, attack *à la débandade*, wheeling off of the fourth subdivisions (platoons,) skirmishing.
   c. Employment and conduct of artillery in action.
5. General principles relative to the combined action of the different arms.
6. Tactical advantages of ground; level, hilly, open, close, uninclosed, and broken ground.
7. Attack and defense of localities, such as heights, woods, farm-buildings, villages, and defiles; false attacks, demonstrations.

C. *Field Service.*

1. Of Marches. General rules, method, and object; precautions, van and rear guards, covering parties.
2. Escort of transports of powder, provisions, and prisoners of war, in one's own and in an enemy's country.
3. Surprises, ambuscades, and reconnaissances.
4. Service in cantonments, camp, and bivouac, outposts, picquets, advanced picquets, reserve picquets (movable and stationary,) patrols.
5. Taking up quarters in ordinary marches and cantonments.

III. FORTIFICATIONS.

A. *Field Works.*

1. Object of breast-work and ditch profiles in plains. Plan of field-works; open works, salient angle, its dimensions.
2. Dead angle and dead ground. Removal of dead ground; flanking; line of defense; dimensions of re-entering angle.
3. Inclosed works; dimensions and space inclosed; works with salient angles only, and with both salient and re-entering angles.
4. Erection of works to be defended by artillery; firing *en barbette*, and through embrasures; platforms; magazines.
5. Communication with interior of inclosed works.
6. Artificial obstacles for strengthening field-works; requisites for their selection and application; method of construction; advanced ditches (demi and entire;) trous-de-loup; abattis; palisades and fraises; barriers; chevaux-de-frise; pickets; caltrops; harrows; sluices and inundations; fougasses; block-houses; caponiers; double, single, and demi-caponiers *à revers*.
7. Strength of garrison of field-works.
8. Defilading, horizontal and vertical, of open and inclosed works; traverses and bonnettes.
9. Construction of small open and inclosed field-works; marking out; tracing; profiling; number and employment of workmen; excavating the ditch; formation and revetment of the slopes with sods, fascines, wicker-work, gabions, sand-bags, wood, or stones; selection, preparation, and application of the revetting materials. (Of the execution of the revetment only so much as may show

whether the examinee will be capable of undertaking the direction of such works in an efficient manner.)

10. Fortification of heights and defiles.

11. Object, general arrangement, and advantageous situation of a tête-de-pont.

12. Arrangements for the defense of woods, hedges, houses, churches, and churchyards.

13. Attack and defense of a redoubt; surprise; attack by open force.

14. Repairing and destroying roads, fords, and bridges, wooden and stone; construction of foot bridges, carriage bridges, bridges across swamps.

B. *Permanent Fortifications.*

1. Construction of a bastioned front in a plain, with ravelin, tenaille, and covered way, in plan and profile, after the first system of Vauban, with the improvements of Cormontaigne; name and destination of every single part, angle, and line.

2. Brief description of a regular attack upon a bastioned fortress; sketch of the preparations for attack; lines of circumvallation and contravallation.

Description of parallels, approaches, demi-parallels, and the duties of the infantry in them; saps, trench cavaliers; carrying the covered way, crowning the glacis, passage of the ditch, escalade of the rampart. These operations to be detailed according to their object, position, and arrangement, but without special reference to their technical execution.

General notions relative to the batteries of a besieging army, their position, object, calibre of guns, and practice.

3. Outlines of the system of defense of a fortress relative to the employment of infantry and cavalry in garrison, and of the standing artillery in arming the fortress and placing it in a state of defense against a regular attack or an attack by open force in all its stages.

Especial knowledge of the duties of infantry and cavalry in garrison, in guarding, occupying, and defending the works, and in sallies, required.

4. Historical sketch of an actual siege (on which the examinee has attended a lecture,) and the principles of the attack and defense of fortresses in general.

5. Account of the situation, form, arrangement, and object of some of the means employed for increasing the permanent strength of fortresses, exclusive of the more technical points.

a. The rampart of the body of the place. Angle of the bastions and its effect; length of flanks and faces; auxiliary flanks; empty and solid bastions attached and detached fausse-brayes.

The escarp, earthen wall, revetment, demi-revetment, simple crenneled wall, arched crenneled wall, revetment *en décharge;* perpendicular and parallel casemates.

b. The main ditch, dry, wet, and dry or inundated at pleasure; sluices, coffer-dams, reservoirs.

c. Outworks. Ravelin, tenaille, counterguards, cover-faces, envelopes, tenaillons, lunettes.

d. Advanced works. Simple and double tenaille; horn-work before a bastion or redoubt; crown-work; double crown-work; advanced ditch, with advanced covered way.

e. Detached works, open or inclosed at the gorge.

f. Interior works. Outs inside the bastions; réduits; citadels.

6. Historical notions of the characteristics of some of the principal systems of fortification, *e. g.* the old and modern Italian, the old Dutch, Vauban's second and third manner, the ideas of Coehorn, Rimpler, the French school, and that of Montalembert, compared with Vauban's first system, but without statement of proportions; in addition to this, the characteristics of the latest Prussian fortifications, always with the omission of details more especially technical.

7. Modified methods of attack; surprise, assault, bombardment, blockade; explanation and statement of circumstances in which attacks of this kind are practicable.

IV. SURVEYING AND DRAWING PLANS.

1. Knowledge of the instruments generally employed in military surveying, and their use.

a. Instruments for measuring and marking out straight lines; viz.—
Signals, bandrols, or *jalons*, common staves, picket posts, rods, measuring chains, measuring cord, the step.

b. Instruments used for protracting the lines measured, viz.—
The step measure, calliper compasses, beam compasses, dividing and reducing compasses.

c. Instruments for measuring and marking out horizontal angles:
The square, the plane table, caloptric compasses, the reflector, the sea-compass, the prismatic compass, the astrolabe:

d. Instruments for measuring vertical angles:
Lehmann's dioptric rule, Schmalkalder's holometer, the quadrant.

e. Leveling instruments:
The ordinary mason's level, the spirit level, the water level, the spirit level *à lunette*, the plumb rule, Lehmann's dioptric rule in connection with the plane table, placed horizontally, the surveyor's rule, Schmalkalder's holometer.

2. Operations in surveying with the plane table, astrolabe, reflector, and compass.

3. Topographical survey of a locality (theorectically and practically,) reconnoitring, geometrical triangulation, detailed survey.

4. Hasty or rough sketch of certain objects, and entire (but limited, sections of country.

5. Drawing plans.

a. Notion of the elements of topography; rising and sloping ground, running and standing waters, division of ground in a military point of view, and characteristics of the same; open, inclosed, elevated, hilly, mountainous, broken ground.

b. Theory of plan drawing.

α. The first elements of the science of projection, and the construction of instruments for measuring slopes.

β. Fundamental rules for plan drawing in general, and for drawing mountains in particular. Statement of the various angles of depression of inclined planes through mountainous regions.

γ. Of the horizontals, and the laws dependent upon them, relative to mountainous districts.

δ. On the laws of defiles.

ε. On ascertaining the difference of elevation, and drawing profiles.

ζ. View of the accessories of plan drawing; the choice of colors and of type, and the order in which the operations necessary for preparing a plan are performed.

c. Practical plan drawing from copies and models.

V. MILITARY COMPOSITION AND KNOWLEDGE OF THE SERVICE.

A. *Exercises in Military Composition.*

1. Drawing up reports on incidents connected with the service, and with the duties of a subaltern officer, directed to the military authorities and superior officers of every rank.

2. Instructions to subordinates.

3. Applications and memorials.

B. *Acquaintance with the General Regulations of the Service.*

1. The laws on disciplinary and military punishments.

2. The proceedings in courts-martial, drum-head courts-martial, and courts of honor.

The preparation for this second, severer, and professional test that has just been described, is usually obtained in the division schools, of which an account will short'y follow, and to which any young man once accepted as a candidate, who has served his six months with the troops, and has passed his preliminary or ensign examination, may be admitted, even though a vacancy has not yet occurred, and he has not yet received his definitive promotion to the ensign's grade.

V. MILITARY SCHOOLS FOR PREPARING OFFICERS.

The Cadet Schools or Cadet Houses.

The actual military education of Prussia commences with the cadet houses, the schools intended for pupils before entering the army. They are divided into two classes, the junior and the senior. They can not indeed be called exclusively military schools, since the education which most of their pupils receive is one which fits them for civil professions, and is not specially military; and there is no obligation even on those who have received the largest amount of pecuniary assistance to enter the military profession when they leave the cadet house. The highest class, however, of the Upper Cadet School of Berlin, called the *Selecta*, receives strictly military teaching for a year, and the schools may fairly come under this denomination, as being mainly intended to educate the sons of officers who are in want of assistance, and as possessing a military discipline, uniform, and spirit.

These are five in number, four preparatory schools, and one a finishing institution; the four first in the provinces, at Culm, Potsdam, Wahlstatt, and Bensberg, the last in the capital itself. At the four junior schools, boys may be admitted at 10 or 11, and may remain till 15; at the upper school the ordinary stay is from 15 or 16 to 18 or 19.

The whole constitute together a single body, called the cadet corps. Boys may enter the school at Berlin on passing an examination, without previously attending one of the lower schools; but those who are sent up by the authorities from Culm, Potsdam, Wahlstatt, and Bensberg, are received without examination, being already members of the corps. A single officer exercises the command of the whole; and a single commission, of which the general inspector is chairman, regulates all matters relating to the admission of candidates into the body.

The whole number at present is between 1,100 and 1,200, of whom 420 are in the Upper School at Berlin, 205 in the Preparatory School at Potsdam, and 200 at each of the other houses.

The cadets are of two kinds, the King's cadets and the Pension-

ers or paying pupils; the former are 720 in number, the latter about 420. The pensioners pay 200 dollars (30*l.*) a year for board and instruction together; the King's cadets are aided in various degrees accordingly to the following scale:—

240 pay 30 dollars (4*l.* 10*s.*) each.
240 pay 60 dollars (9*l.*) each.
240 pay 100 dollars (15*l.*) each.

Foreigners are admissible at a yearly payment of 300 dollars (45*l.*,) and a few extra day scholars (*Hospitanten*,) when the classes are not too full, are received for 20 dollars a year (3*l.*)

The King's cadetships are granted, according to the pecuniary circumstances of the applicants, to the children of officers of the standing army, or of the Landwehr, who have distinguished themselves or have been invalided in actual service in the field; to the children of non-commissioned officers who have in like manner distinguished themselves and received severe wounds in the service; and to those of any citizens who have performed any special service to the state. The sons of meritorious officers who have died in indigence or have retired upon pensions, the sons of indigent officers in general in the standing army, and the sons of meritorious non-commissioned officers of twenty-five years' standing, are also in like manner eligible.

In very special cases of poverty, the supplementary payment is dispensed with altogether.

Pensioners are admitted from all classes and professions according to priority of application, and to their qualifications as shown by their examination. A great number of these are said to be the sons of officers, of those, namely, who are not in need of pecuniary assistance. And the number of the pensioners generally appears to be steadily on the increase. In the regulations printed in 1850, the places open for this class of cadets are stated to be only 216; at present, as has been seen, provision is made for something like double that number.

The four junior schools at Culm, Potsdam, Wahlstatt, and Bensberg, are all divided for purposes of instruction upon the same uniform plan into four classes, numbered up from six to three—*Sexta* at the bottom; *Quinta; Quarta;* and *Tertia* at the top. The upper school at Berlin succeeds with three classes, the second, the first, and the special or select—*Secunda*, *Prima*, and *Selecta*. Each of these classes, however, may contain any number of co-ordinate subdivisions, all taught the same subjects, and presumed to contain pupils of the same capacity. No teacher, it is considered, can satis-

factorily undertake to give a lesson to more than thirty at a time; and the Secunda at Berlin was thus parted out in the year ending March, 1856, into eight little sets of rather less than thirty, the Prima into six, and the Selecta into two.

Junior Cadet House.

The junior cadet house at Potsdam occupies four or five buildings a little way out of the town. The class-rooms are on the usual Prussian plan, not arranged for lectures to large, but for lessons with small numbers. One distinguishing feature is the character of the arrangements of the rooms up-stairs, in which the boys pass their time out of school hours. They are very comfortable chambers, perhaps rather small for the numbers at present placed in them; they are ranged along a corridor; ten pupils are placed in each, and between every two rooms is the apartment of one of the resident tutors (*Erzieher* or *Gouverneur*,) who sees that all goes on right in these two rooms under his charge. Here the boys sit and work, and during the hours when they are expected to be preparing their lessons, are carefully looked after by their tutors.

These little apartments occupy one whole floor of the building. The floor above is that of the dormitories, containing each, perhaps, as many as sixty. The number at present in the school was stated to be two hundred and five, and the accommodation properly intended for only one hundred and sixty.

Colonel von Rosenberg, the commandant of the school, stated that eleven was the usual age at which the pupils came. This he appeared to think was rather too early, and he was inclined to attribute to this cause certain points in the character of young men who have been educated in the cadet corps. Eighty of his two hundred and five pupils were pensioners, or paying pupils; many of these also were the sons of officers. The teachers and tutors are partly civilians and partly military men, about an equal number of each. The four classes, Tertia, Quarta, Quinta, and Sexta, are subdivided into nine, so that the average number at a lesson would not be more that twenty-three.

Senior Cadet House.

The upper or central cadet school is in the older part of Berlin, in the *Neue Friedrichs Strasse*, where on the pediment surmounting the gateway the inscription, MARTIS ET MINERVÆ ALUMNIS M.DCC. LXXVI, records the erection by Frederick the Great, ten years before his death, of the large and stately quadrangle which formed the original house. Here the pupils are quartered, and in the great

court within, they go through their exercises. There are several houses on both sides of the street attached to the service of the institution, and buildings are in course of erection to accommodate additional numbers.

A large separate building contains the present class-rooms. In the first of these which we visited, thirty cadets were engaged in military drawing; in another, twenty-four of the second class, the Secunda, were busy at their Latin lesson.

The room was fitted up on what appears to be the usual plan, with a series of parallel desks on the same level, ranged along the outer wall, and a sufficient space between them and the inner wall for the teacher to pass freely up and down. His desk was at one end in front of the boys. The lesson was in Quintus Curtius. The teacher (a civilian) made them construe each a sentence, and asked questions in parsing, &c., &c., much in the English manner. There was no taking places. This in German schools appears to be confined to quite the lower classes. There is a separate lecture-room here again for lessons on Natural Philosophy and Chemistry, with a small gallery of models, instruments, &c., attached to it.

A large hall is used on state occasions, and serves the purpose also of an examination-room; it is called the hall of the Field Marshals, and is adorned with portraits of the sovereigns of Prussia from the Great Elector downwards, and of the field marshals both of the time of Frederick the Great and of more recent date, among whom is the Duke of Wellington. Here also is kept Napoleon's sword taken at "La Belle Alliance," and presented by Marshal Blucher.

Passing to the first floor of the great quadrangular building, we found ourselves in one of the sitting-rooms of the cadets. Seven boys had a couple of rooms, consisting of a common sitting-room, and a common bed-room. Five is the number for which this amount of accommodation was intended, and to five the number will be reduced when the new buildings are completed. In a second and larger pair of rooms we found twelve boys.

Here also is the library, containing 10,000 volumes, and comfortable apartments occupied by the various superintending officers.

The boys, their morning lessons completed, had been going through their military exercises under the superintendence of their officers; but they were now collected in their studying-rooms, and were seen forming at the doors, each small party under the command of its senior, ready to march into the large and handsome dinner-hall.

Into this the whole body of young men presently moved by companies, proceeding to station themselves in front of the tables. The tables are ranged in parallel lines on each side of the central passage, and accommodate each of them ten, four sitting at each side, and a senior at each end. The order was given by the officer on duty for "prayer" (*Nun beten wir,*) and a short silent grace was followed by the immediate occupation of the seats, and the commencement of the meal. The arrangements in general appeared to be excellent.

The number in the school during the past year had been 420. The four companies into which the whole body of the pupils is divided, each contain a certain proportion from each of the three classes; the senior in each company being invested with the charge of the juniors; those who are in the Selecta taking rank as under officers. In every room (*Stube* or *Wohnzimmer*) there is one *Selectaner*, who is responsible. The ordinary ages are 15, 16 in the Secunda; 16, 17 in the Prima, and as far as 19 in the Selecta. No one is, as a rule, allowed to pass more than one year in a class; if in that time he can not qualify himself for advancement, he is dismissed. The rule does not, however, appear to be strictly enforced. The general preservation of discipline appears to be a good deal intrusted, as in English public schools, to these senior pupils of the age of eighteen or nineteen. There are Resident Tutors (*Erzieher* or *Gouverneurs*) as at Potsdam, who see a good deal of the pupils, especially in the evenings, when they go into the sitting-rooms, sit with them, help them in their work, play at chess with them, &c., &c. But they do not sleep close at hand between the sets of rooms, as at Potsdam, but at some little distance off.

The official arrangements for the control of the discipline consist principally in the system of what are called *Censur* Classes. This is a peculiar system which requires some explanation. There are five *Censur* Classes quite independent of the ordinary classes of the school. A boy on entering the Cadet School is always placed in the third of these classes; if he behaves ill, he falls to Class IV. and is under restrictions. Class V. is reserved for serious cases of misconduct, and any one who incurs the penalty of descending to it, is subject to continual superintendence, and is confined to the walls. Class II. gives considerable, and Class I. still more ample privileges. The members of this class (usually only quite the elder boys) are allowed great freedom in the way of going out into the town.

In each of the studying-rooms (the *Wohnzimmer*) the list of the occupants' names hangs up on the door inside. One for example

was noticed containing twelve names. To each was attached his rank in the *Censur* Classes, as well as his position in the ordinary classes. At the head stood one *Selectaner*, who in this instance was in charge of the room; then followed the *Primaners;* and the list was completed by nine of the *Secunda*. As at the time of our visit (just after the Easter holidays and the yearly examination) the whole Selecta of the year had just quitted, the room was in the charge of the senior *Primaner*. The authority exercised by these senior boys appears to be very considerable.

The competition for admission to the Selecta, and for the after selection for immediate promotion, was spoken of as very considerable.

The number who came to the Berlin Cadet House without previously going to one of the junior establishments was said to be only a small per-centage.

The boys both here and at Potsdam were of course all found dressed in a military uniform.

The studies pursued in the Cadet Corps agree nearly with those of the common public schools, but of these there are three different kinds:—

1. The ordinary first-class school, the *gymnasium* of the Prussian States, is, strictly speaking, a school which prepares for the universities.

2. The second-class schools have the name of *Real* or *Practical Schools;* they deal with the actual application to business and work, not with the theory of mathematics or of language, and they may be said to resemble in some degree the schools occasionally attached in English towns to Mechanics' Institutes, or in the United States, to the Public English High School or the Higher Department of a Union School. Young men who have passed successfully through a gymnasium may be admitted to the army without passing the preliminary or *Portepée-fähnrich* examination. Those who complete their time at a *Real* School have not hitherto been allowed the same privilege.

3. There is a third and intermediate class called a *Real* or *Practical Gymnasium*, and to this, according to the statements of the official books, the courses of the Cadet Schools have hitherto corresponded. It appears, however, that there is only one specimen of the *Real Gymnasium* now in existence, the Coëln School in the old town of Berlin. The system here is said to be more practical than the *Gymnasium*, and less professional or mechanical than the *Real School.*

It is intended during the present year to assimilate the course of instruction at the Cadet Schools more nearly to that followed at the *Gymnasium* or University School; the studies of the senior Cadet School at Berlin will be raised to a higher standard, but Greek and Hebrew, which are taught in all gymnasiums, will not be introduced.

The two systems have corresponded as follows:—

Class in the Cadet Corps.	Age.	Corresponding Class in the *Real* Gymnasium.
6th, or *Sexta*,	12	6th, or *Quinta*.
5th, *Quinta*,	13	4th, *Quarta*.
4th, *Quarta*,	14	Under 3d, *Unter-Tertia*.
3d, *Tertia*,	15	Upper 3d, *Ober-Tertia*.
2d, *Secunda* (at Berlin,)	16	Lower Second, *Unter-Secunda*.
1st, *Prima*,	17	Upper Second, *Ober-Secunda*.

The Selecta, the Military Class, corresponds with the classes of the Division Schools, and with the first year's course of the Artillery and Engineers' School.

The plan pursued, both as regards, first, the subjects taught, and second, the amount of time, is as follows:—

The instruction consists throughout, from *Sexta* up to *Prima*, of lessons in Latin, German, French, Arithmetic, History, Geography. Natural History begins in the *Quinta*, at 12 or 13 years old, with Botany and Zoölogy; Mineralogy follows, at 14 or 15; Natural Philosophy at 15 or 16. The first elements of drawing, with the use of rulers, compasses, &c., begins also in *Quinta*, at 12 or 13. Practice in regular plan-drawing is gradually and increasingly given in every year. The first elements of geometry are taught in the *Quarta*, and Euclid I. 47. *Pythagoras*, has to be mastered at 14 years old. Theoretical Arithmetic, in combination with Algebra, is commenced apparently in the *Tertia*.

The subjects taught in the *Secunda*, *Prima*, and *Selecta*, that is, the course of the Upper School at Berlin, has hitherto been as follows:—

In the Secunda:

Quintus Curtius, Cicero's Orations, and Ovid's Metamorphoses; in Mathematics, the completion of Plane and commencement of Solid Geometry; Quadratic Equations; the Physical, Statistical, and Ethnographical Geography of Europe; Ancient History, and History of the Middle Ages, down to the Thirty Years' War; a first course of Natural Philosophy; French and German Composition continued; Theory and Practice of Military drawing.

In the Prima:

Livy and Virgil; in Algebra, Progressions, Logarithms, Exponential Equations; Trigonometry, Mathematical and pure Physical Geography in general; Modern History; second course of Natural Philosophy, Heat, Electricity, Magnetism, Sound, Light; French, Exercise in Speaking, &c.; History of German Literature; Composition, extempore Exercises; Military Drawing continued.

In the Selecta:

Arms and Munitions, and Artillery; Fortification, Tactics, Military Literature Practical Exercises, Military Drawing and Surveying; exercises in French and German; Mental Philosophy; Chemistry; and the Differential and Integral Calculus for those who propose to enter the Artillery or the Engineers.

The Secunda have weekly—

6	hours	of Latin.
3	"	of German.
4	"	of French.
5	"	of Mathematics.
2	"	of History.
2	"	of Geography.
2	"	of Natural Philosophy.
2	"	of Lessons in Drawing.
2	"	of Religious Instruction.
2	"	of French Conversation.
Total,.....	30	hours weekly.

The Prima—

The same amount in Latin, German, French, Mathematics, Natural Philosophy, French, Conversation, and Drawing; in History 3, and in General Geography 2, and Mathematical Geography 1; of Religious Instruction 1. 33 hours weekly.

The *Selecta* have—

4	hours	of Tactics.
2	"	of Military Literature.
1	"	of Military Law and Regulations.
5	"	of Artillery.
5	"	of Fortification.
2	"	of Plan Drawing.
2	"	of Mental Philosophy, or English.
2	"	of Chemistry.
2	"	of Mathematics.
2	"	of French.
2	"	of German.
Total,.....	29	hours weekly.

The lessons appear to be going on from 8 to 11 or 12 in the morning, and from 2 to 4 or 5 in the evening. The pupils have two hours' drill twice a week. They get up at half-past 5, have breakfast, and an hour's preparation before lessons begin. There are similar hours of study in the evening from 6 to 8; and some of the pupils also take private lessons from the teachers.* During these special hours of study (*Arbeitstunde,*) the chambers are visited by the officers and tutors, assistance is given and diligence enforced. From 8 to half-past 9 they study as they please; the tutors are a good deal with them in the rooms; at 10 all are in bed. Wednesday and Saturday are half holidays; on Sunday they

* Not from the Tutors, but from the non-resident Professors and Teachers.

attend morning service in the garrison church, and after that is over, are allowed to be more or less absent in the town, to be with their parents, relations, and friends.

For the 420 cadets of the Institution at Berlin, there appear to be about twenty professors and teachers not residing in the school, the majority of whom are civilians; and in addition to these, twenty tutors and superintendents resident in the buildings. Of these, sixteen are military officers, half of whom are permanently attached to the corps, and half on duty from various regiments, and four are civilians. The cadets being divided into four companies, each containing so many of the Selecta, so many of the Prima, and so many of the Secunda, to each of these companies are attached one captain, one first-lieutenant, and two second-lieutenants, all of whom, however, take some part in the instruction; and one civilian (*Civil-Erzieher*) is added with the especial duty of looking after and assisting the studies of the cadets of the company.

The holidays are one month in summer (in July and August,) ten days or a fortnight at Christmas, eight days at Easter, and four at Whitsuntide.

The rules for the entrance of cadets into the army are as follows:—Those who complete their year in the Prima are considered to be sufficiently prepared for ordinary admission. They are sent in to an examination before the Supreme Examinations Board (the *Ober-Militair-Examinations-Commission*,) before examiners entirely independent of and unconnected with the instruction of the cadets; and the majority, if they pass, are admitted simply as *Portepée-fähnriche*, on the same conditions as the young men already spoken of who enter upon the recommendation merely of the commanding officer of a regiment and the approval of the commanding officer of an army corps. Like these, they serve in the regiment, they attend the Division Schools, and in due time offer themselves for examination for a commission.

Out of this number, however, the sixty who do best are retained, and reserved to receive in the special military class of the Cadet School the instruction which the others are to seek in the Division Schools. These remain another year in the Cadet House, and undergo at its close, before leaving the Cadet House, their officers' examination before the Supreme Board. The thirty best are once more selected, and receive immediate promotion. Their patents are signed and they join their regiments at once as second-lieutenants. The other thirty, if they have satisfied the examiners, receive a certificate of qualification, and enter with the rank of *Portepée-*

fähnrich, and with the prospect of receiving commissions without further examination, as soon as vacancies occur. Any one who fails to pass his examination must enter, if at all, simply with the rank of *Portepée-fähnrich*, and has to qualify himself in the Division Schools for attempting a second time the examination for the officer's patent.

Such is the system as recently modified. Till quite lately only thirty were promoted from the Prima to the Selecta, and these thirty, unless they failed wholly, obtained immediate commissions at the end of the year. It has been found desirable to introduce the stimulus of competition, to offer a definite reward in the way of superior advantages to the best students, and to make it obviously worth a young man's while to exert himself, and to be thoroughly diligent during this final year in the Selecta at the Cadet School.

Young men who, after passing the examination in the Prima, desire to enter the artillery and engineers, follow the usual course leading to the Artillery and Engineers' School. They enter an artillery regiment, or a division of the engineers; they serve for nine months, they enter the special school, they are eligible after the first quarter to the grade of *Portepée-fähnrich*, and at the close of their first year are examined for their lieutenant's commission. Those who remain in the Selecta have the great advantage of passing from the Cadet School immediately into the Artillery and Engineers' School as lieutenants, and commence their course there accordingly at the beginning of the second of the three years. As, however, the school-year closes at the end of April, in the Cadet Houses, and begins in the Artillery and Engineers' School on the 1st of October, these select cadets also pass five months with their regiment in actual service before recommencing their studies.

The average number who pass in this manner into the Artillery and Engineers' School is stated by the authorities of the Cadet House to be three annually from the Selecta, and six or eight from the Prima.

It can hardly have escaped observation, that the studies pursued as a qualification for entering the army are, with the exception of the Selecta, almost entirely non-professional, even here in this part of the general system, which is in other respects most military in its character; and the tendency seems to be to carry out to a still greater extent the theory of continuing to as late an age as possible a good general education. There is evidently a general desire in Prussia to take the officers of the standing army exclusively from the well-educated or the higher classes.

In the arrangements for the lessons, the very temperate or even timid use of the stimulus of competition deserves to be noticed. It appears, however, to have been lately employed with advantage in the highest class. At the same time, the provision made for giving really good instruction, and for placing all the boys in close relation with their teachers, can not but excite admiration. The small numbers of which the classes consist, and the care which seems to be taken in providing good teachers, both deserve attention.

The domestic arrangements, without being remarkable for the scrupulous cleanliness or the magnitude of the new institutions in Austria, certainly in some respects are more in accordance with English feelings. The greater privacy afforded by the use of rooms where few live together, is certainly more analogous to what has been found most desirable for English boys in large English schools, though most likely the contrary system is not less well-adapted to the national character in France and in Austria.

2. *The Division Schools.*

There are nine Division Schools for the whole army, one for each army corps, and they are placed at the following towns:—

Potsdam, Königsberg, Stettin, Frankfort on the Oder, Erfurt, Glogau, Neisse, Münster, and Trèves.

Here the young aspirant finds himself with nine or ten companions and a body of teachers amounting to about half that number, appointed by the commanding officer of the army corps, and differing considerably in different districts in their talents and ideas of education. They are often, though not always, selected from officers who have been at the Staff School, and afterwards at the Topographical Bureau. Their additional pay for teaching is uncertain; it depends upon the surplus remaining after the expenses of the household, and the money paid in purchasing books, instruments, &c., is deducted from the yearly allowance made to the school by the government. At best it is not high. It is calculated by the number of lectures, and at the most amounts to something more than 4*l.* 10*s.* (30 thalers) for the lectures on a single subject, given, it must be remembered, during the course of little more than six months in the year. The highest pay given in the Potsdam School to any one professor amounted to something more than 15*l.* (100 thalers) yearly for lectures on three subjects, averaging ten or twelve lectures weekly for about six months. This must be estimated by a Prussian, not an English standard, being nearly equivalent to five-twelfths of the annual pay of a second lieutenant in that service.

Still the sum is very low; and this, with some other obvious deficiencies, injures the working of the schools.

The young candidate for a commission begins a course of Tactics, Fortification, theory of Drawing and Surveying, Military Literature, Artillery, &c., Military Essays, and Drawing of Plans, which must be finished at the school in nine months, although it may be continued longer in private if the candidate is not prepared to pass his examination. As long as it lasts, twenty-three hours a week are devoted to study, besides the time occupied by questions, which the teachers are required to set from time to time, in order to keep up the pupil's previous knowledge of French and Mathematics. The course is divided into the purely theoretical and practical divisions, the first of six and a half months, the latter of two and a half. We have already given a very full account of the studies in p. 188.

The arrangement of studies is systematic, and the number of hours devoted each week to lectures on the various subjects of study and to gymnastic riding and fencing, is as follows:

WEEKLY:

	Hours.
Fortification,	4
Artillery, &c.,	3
Tactics,	4
Military Surveying (theoretically,)	4
Military Literature,	2
Instruction on Military Duties,	1
Plan Drawing,	5
Gymnastics,	2
Riding,	2
Fencing,	2
Total,	29

The subjoined plan gives the exact employment of time for each day during the week:—

PLAN OF LECTURES AT THE DIVISION SCHOOL IN POTSDAM, 1855–6.

Hours.	Monday.	Tuesday.	Wednesday.	
8— 9	Fortification.	Military Literature.	Tactics.	Dinner time, 3 o'clock. Time for studying, from 6 till 8 o'clock, or from 7 till 9 o'clock every evening.
9—10				
10—11	Instruction on Military duties.	Artillery, &c.	Plan drawing.	
11—12	Plan drawing.	12½–2½ Gymnastics.		
12— 1				
	Thursday.	**Friday.**	**Saturday.**	
8 — 9	Fortification.	Artillery	Tactics.	
9 —10				
10 —11	Military Surveying (theoretically.)	Plan drawing.	Military Surveying (theoretically.)	
11 —12				
12½—2½	Riding.	12½–2½ Fencing.		

The lecturer has to draw up what is called the thread of the lecture (*leitfaden*,) a sort of programme containing its leading heads, intended to assist the memory of the pupils in giving a full account of it afterwards; and the contents of the different lectures on Tactics, Arms and Munitions, Fortifications, &c., are written out very minutely by the students. Ten pages of close print are devoted to these programmes in Helldorf; and the translation already given (pp. 188–194) will show that the list of military subjects adverted to is considerable.

At the end of the nine months spent at the Division School, the "*Officier Aspiranten*" go to Berlin for the examination for their commission. If they can not pass this, they return to study by themselves for their second trial. Unless by special permission from the King, they can not try more than twice.

The examination is conducted by the Supreme Commission for Examinations at Berlin, and has been already described.

The Division Schools were founded at the end of the great War. Their germ appears in Scharnhorst's general order in 1810, which, among other things, instituted three War Schools for the candidate for commissions (*Portepée-fähnriche.*) These three War Schools seem to have been changed into the Division Schools in 1813 and 1816. At first, indeed, they were much more numerous than at present, as their name implies, there being two Divisions to each Army-Corps. There are now, as we have mentioned, nine; and Corps School or Army-Corps School would be the more correct designation.

Their importance as the institutions for special military instruction to all "*Officier-Aspiranten*" of the army led us to inquire carefully with regard to their efficiency, and in particular from two distinguished officers, on whose judgment and scientific experience great reliance might be placed. One of these, it may be added, possessed constant means of knowing all the details respecting them.

I. Formerly, it appears, it was not possible to limit these schools to their true object, purely military instruction. This was the special object of their creation; but owing to the defective *general* education which candidates often brought with them into the army, the Division Schools were too much used as a means of meeting this deficiency.

II. The opinions we obtained were certainly not favorable with regard to the present efficiency of these schools. It seemed to be agreed, that from various reasons, the military education given was

susceptible of much improvement; that some of the Division Schools were really defective in teaching, whilst none could be pointed to as strikingly good. But it was also admitted that these blemishes arose from remediable defects in the working of the schools; that their principle was in itself sound, and capable of being carried out more perfectly, and excellently adapted to the object of giving some military instruction to all desirous of becoming officers of the infantry and cavalry.

III. The causes assigned for the present defects in the efficiency of the Division Schools were chiefly the following:—

(*a.*) That they were far too numerous.

Educated and scientific as Prussia may be called, it is not found practicable to supply *nine* army schools with exactly the sort of men fitted for the work of education. The pay, it must be added, is insufficient to attract many, and thus (as we were informed,) although many officers of intelligence are sometimes not unwilling to leave the life of drill for the life of education for a year or two, few do so with the serious purpose of doing it *well*. Neither the position nor the emoluments tempt them to make it a profession. Officers in command of the district have made the appointments, and often have "good-naturedly," as it was said, appointed unfit persons, known as studious men.

(*b.*) The small number of pupils in each school was also spoken of as a very great disadvantage, as doing away with all emulation amongst themselves.

(*c.*) The independence which each school has enjoyed, and the want of any central body to watch its working and regulate its system, is also said to have had bad results. The teaching has been far from uniform,—in one school energetic, in another lax; in one school the most important subjects taught, in another, a little of everything; in a third, some special crotchet of a teacher. This has acted badly on the examinations, since it was thought hard to reject an "*aspirant*" who had done parts of his work well, and had been evidently ill taught or superficially instructed in others.

The remedies suggested were,—

(1.) Considerably to diminish the number of these schools. This, we were told, was about to be done by reducing them from *nine* to *three*. Such a course would obviously tend to remedy two of the evils complained of. It would give a larger choice of teachers, and afford more liberal means of remunerating them, and a larger attendance and competition of pupils.

(2.) To place the schools under the more direct regulation and

management of the Central Educational Department at Berlin. This step would improve their teaching by subjecting it to constant inspection and reports. It would insure uniformity in the system of instruction and subjects of study; and, when combined with the presence of able teachers, it would enable the Board of Examiners at Berlin to pursue a more strict and unvarying course in rejecting ill-qualified candidates. By these means the teaching in the school would probably become more definite and higher.

One other point was mentioned to us as doubtful. It was thought that the time for attending the Division School came too soon after a young man's entrance into the army, when he had but recently obtained his liberty, and was likely to be much more unwilling to be sent to school again than might have been the case a year or two later. General von Willisen, who urged this objection to us, was consequently for deferring the attendance at the Division Schools several years in an officer's life.

We should add, however, that as in Prussia a young *Officier-aspirant* is still partly a private soldier, we were told that many were glad to exchange the severity of regimental discipline for the Division School.

3. *The United Artillery and Engineers' School at Berlin.*

Young men desirous of obtaining commissions in the Artillery or Engineers follow the course which has already been described. They join either with a nomination from a colonel of artillery or engineers, or as scholars from the Cadet House. They submit themselves for examination for the grade of Ensign (*Portepée-fähnrich*); they serve their time with the troops, they go through a course of professional study, and are examined in it for their officer's commission by the Board at Berlin. If they come from the highest class, the *Selecta* of the Cadet House, they have the privilege of joining the corps with the rank of officer.

In these respects the system is the same for them as for the *Aspiranten* in the other arms of the service.

The distinctions are, that first, in the preliminary or Ensign's Examination, a somewhat greater acquaintance with mathematics is required from them; secondly, that they prepare for the Officer's Examination, and follow their professional studies, not in the Division Schools, but in a separate Special Arm School at Berlin. Moreover, nine months' service with the troops, instead of six, is required before they can enter the Special Arm School. They enter it also with the rank only of corporal, and are not eligible to the

grade of Swordknot Ensign until they have passed three months at least in the school.

Their Officer's Examination before the Supreme Board at Berlin takes place after nine months more, at the end of the first year at the school, and after passing they are eligible to the rank of officer.

When a vacancy occurs their claim to an actual commission is considered, and the usual formalities are fulfilled. Their names are submitted for approval to the officers of the corps, and with that approbation laid before the King; and they thus in due time obtain their rank as Sub-Lieutenants respectively of Artillery or of Engineers.

This rank, however, is provisional, and their position is that of supernumeraries. Their education as officers may be complete, but their education as officers of Artillery or of Engineers has scarcely in fact commenced. They have before them a third examination, that of the Special Arm, their *Vocation-trial* or *Berufs-prüfung*. Or, more correctly speaking, they have not one but two to pass, for the third examination is divided into two stages, one to be passed at the end of each of the two years which yet remain of the course. It is only when these are completed, after a three years' stay, that the young man is finally allowed to join his corps as a second-lieutenant.

Failure in the officers' examination at the close of the first year is attended with the penalty of returning to the corps and resuming service in the ranks with the troops. Whether or not the rejected student may be permitted to return after an interval to join again the classes of the first year, or after passing, upon a second trial, the officers' examination, to enter the classes of the second year, will depend upon the extent of his failure.

Failure in the examination at the close of the second year is similarly visited with the punishment of return to the corps. As they have already passed the officers' examination, they may endeavor to effect a transfer to a regiment of the line; or, under certain circumstances, they may be permitted to study privately in preparation for the third year's course, and may offer themselves for a second trial.

If a student fails in his last examination at the close of the third year, he may be allowed, in like manner, under favorable circumstances, to re-enter the third year's classes, and try to qualify himself by an additional year of study, losing, of course, his seniority. Otherwise, he joins the corps as a supernumerary, with the pay of an infantry officer, and waits till he can obtain a commission in the line.

Candidates for commissions in the engineers enter the corps, it should be observed, originally as volunteers, finding their own clothing, and receiving no pay; but as soon as they enter the school they are regularly paid by the state, and receive their pay in the usual course of the service from the division to which they belong.

The studies of the three years are arranged in accordance with the system that has just been described. Those of the first year are common to the two arms, and correspond, in a general way, with what is taught in the Division Schools or in the highest class of the Cadet House. Those of the second year are devoted to the special arm subjects. In Mathematics, Artillery, and Fortification, the lectures are common to the artillery and engineers; in drawing they are divided.

In the third year a considerable separation takes place. Mathematics are still taught, and there is a special class of the most advanced students in the Differential and Integral Calculus, the Higher Geometry, and in Analytical Mechanics and Hydraulics; this, however, is purposely restricted to about one-third of the class, by raising the requirements, if necessary.

The course is divided in each year into the theoretical and the practical part. The year commences in October with the former, and the studies for the nine months succeeding are for the most part theoretical only. In June the examinations take place. July, August, and a part of September are given up to practical exercises. Something like the last three weeks of September are allowed for a vacation.

The general control of the school is in the hands of the General Inspectors of the two services, the artillery and the engineers. These two are the *Curators* of the school and form the *Curatorium*. They make their reports to the General Inspector of Military Education, of whom mention has already been made. The immediate management is intrusted to a director, who is a field officer of artillery or engineers, of the rank of commandant of a regiment, and he has a captain, appointed by the *Cutatorium* as his assistant.

There is a Board of Studies, of which the Director is chairman, consisting of the Senior Professor of Mathematics, of the Instructors of Artillery and Engineering in the third Cœtus, and of an equal number of officers of the two services named by the Curators.

Four officers, three from the artillery and one from the engineers, acting under the captain, are charged with the care of discipline and order; these are the *Direction* Officers.

There are twelve military and eleven civilian professors and

ers. Among the military professors and teachers may be included any of the direction officers.

The examinations of the first year are conducted by the usual Board, the Supreme Military Examinations Board; but for those of the second and of the third year, there is a separate board, chosen from the two services by the Curators, and otherwise unconnected with the School.

The numbers in the school vary from 216 to 240. In time of peace about five are yearly admitted for each regiment of artillery, and two or three for each division of engineers. The great majority have entered the army from the usual places of civil education, a few from the Prima of the Cadet House, on the same terms as the others, and a small number, who are usually among the best pupils in the school, from the Selecta, who come as officers, and after a short service with the troops, enter the second year's classes, provided there is room, preference being always allowed to the students already belonging to the school, who have succeeded in passing the examination of the first year.

The Artillery and Engineers' School buildings stand in Berlin itself, in the principal street, *Unter den Linden*, No. 74, near the Brandenburg Gate. They bear the following inscription: *Artillerie und Ingenieur Schule. Stiftung Friedrich Wilhelms* III. M.DCCC.XXII.

On the occasion of our visit to the school, we were allowed by the kindness of the authorities to be present at some of the lectures. The students of the second year were attending the course on the History of the Art of War, and the immediate subject was an account of and criticism on the battle of Blenheim. The young men, about forty-five in number, were ranged in desks facing the Professor, but not in the manner of an amphitheater. The lecture was interesting, animated, and generally instructive; it was perfectly professorial in character, and the young men took notes. A class of the students of the first year, thirty-five in number, were engaged in topographical drawing. The artillery division of the third year students were in another room, listening to and busily taking notes upon a lecture (also professorial) on the construction of gun-carriages: the number was about forty-five.

Only the students of the first year are lodged in the building; and owing to the unusually large number lately admitted, an adjoining house has been taken to afford additional room. The accommodation in general is rather limited. Two stories in the upper part of the building are occupied by the somewhat scantily fur-

nished chambers; there appeared in some cases to be two young men in one room, in other cases four, or as many as six or seven to a bedroom and sitting-room. The students who lodge in the building dine together in a mess-room; and there is a billiard-room, with coffee-rooms adjoining it, for the general use, looking out from the ground floor front into the Unter den Linden. There is a library, a small laboratory attached to the lecture-room employed for the subjects of Chemistry and Natural Philosophy, and a small collection of apparatus required for illustration on the latter subject.

On quitting the school, the engineer students, as soon as they obtain their commissions, are employed for three years with a Division of Engineers; then for three years in a fortress to superintend buildings; and then again with a Division of Engineers. They are then eligible to promotion as first-lieutenants.

The artillery students, in like manner, join and serve with their regiments.

Promotion in the artillery is by regiments, in the engineers it is general throughout the whole corps.

We should not omit to call attention to the fact, that the only instance which has come to our knowledge of the promotion of *officers in their own arm of the service*, being made contingent on their passing an examination, is to be found in the Prussian Artillery and Engineers. First-Lieutenants belonging to those corps must pass an examination before they can be promoted to the rank of captain. This regulation does not exist for any other part of the Prussian service, and it is considered a great grievance by the officers of those corps, as it may be exacted at the age of forty, from the most highly educated officers of the Prussian army.

The pay of subaltern of engineers is somewhat higher than that of the artillery, infantry, and cavalry. Above the rank of subaltern, the pay of the artillery, cavalry, and engineers, is on an equality, but superior to that of the infantry. The engineers have, moreover, a prospect of employment of a civil nature when they return from active service; to lucrative positions of this kind they are not unfrequently appointed.

It should be mentioned before quitting the subject, that all the officers of the artillery and engineers are bound, in consideration of three years' maintenance in the school, to serve a period of six years, before they can exercise the usual privilege allowed to Prussian officers of withdrawing from the service.

[*A particular account of the Course of Instruction in this School will be given in a separate article under the title of the Institution.*]

VI. SCHOOL FOR STAFF OFFICERS AT BERLIN.

The War School (*Kriege-Schule*) in Berlin has undergone many changes since its foundation in the time of Frederick the Great. It is now the Staff School of Prussia, *i. e.*, the only, or almost the only, means of obtaining a staff appointment is by passing through it, and the education given is particularly intended to form staff officers. Its plan and methods of teaching differ, indeed, from the very commencement from the French Staff School, and bear much more resemblance to the senior department at Sandhurst, with the exception that the senior department is not at present a necessary means towards a staff appointment.

Thus the *Kriege-Schule* does not take young men of twenty-one or twenty-two and educate them (like the French Staff School) for the staff and the staff alone. Its pupils are men of twenty-five or twenty-six, officers of three years' standing, or five years' service since their first entering the army. At this comparatively ripe age they become candidates for entrance to the Staff School, and, if admitted, they spend there three years of laborious study, with no very brilliant prospects to crown it, as only a very small number obtain what may be called the lowest prize, admission to the Topographical Department; and out of these only two or three yearly of the most distinguished pupils gain the Staff. The rest return to their regiments, and are employed as adjutants or as teachers in the Division Schools.

The process of entrance is as follows:—An officer of three years' standing desires to go to the Staff School. Any one may send in his name as a candidate for the entrance examination to the minister of war, having obtained a certificate from his superior officer that he understands his regular duty, has no debts, and is capable, both as regards his abilities and bodily strength, of making a good staff officer. Little difficulty is made about admission to become a candidate, nor is there any regulation to limit the number from any one corps or regiment, so that there may be often found in the Staff School more in proportion from the infantry than the cavalry, and *vice versâ*. Some regiments, we heard, hardly ever send officers to the school. Practically, indeed, the regulation requiring three years of active service bears hard upon the artillery and engineers in comparison with the other services; for, as the officers of these two corps only enter their own school after they have been near a year in the service, and spend three years there, they must have been in the army nearly seven years before they can enter the Staff School.

The candidate for the Staff School is examined in the capital of the province in which his corps is stationed. The examination is early in April, and it is held at the provincial town instead of Berlin, in order to diminish expense. But the questions are sent from the board of examiners in Berlin, and the same are given in the different provincial towns at one and the same time. The examination is much on the same subjects, and requires about the same actual knowledge as that which was passed at least three years before for a lieutenancy, but owing to the difference of age, the questions are put and are expected to be answered in a much more scientific form than on the first occasion. Thus, we were told, such an essay as "Give an account of the wars of Francis I. and Charles V.," would at the *Kriegs-Schule* Examination rather be stated thus: "What was the influence of these wars on the policy and religion of Europe?"

The examination is entirely upon paper; it occupies from ten to twelve days of about five hours daily, the superintending staff officer in the province presiding over it. But his business is limited to reading out the questions sent to him, and taking care that no books are brought in, or any improper means used. The answers to the questions have to go through a double ordeal, the military ones being first examined by some of the staff of the general commanding in the province, and afterwards by the commission of examiners at Berlin. The final decision rests with the chief of the Prussian staff, who recommends the successful officers to the minister of war.

There is an average of sixty or seventy candidates yearly. Only forty of these can be taken. If some additional case seems meritorious, the officer may obtain a promise of appointment, but his entrance is deferred. It is not uncommon to try more than once.

The entrance examination passed, the school opens on the 1st of October, to continue its lectures, with a fortnight's break at Christmas and at Easter, till the first of June. It has its 120 pupils, divided into their three classes, one for each year, working (with only little of practical work) under professors, military for the lectures of a military, and civil for those of a non-military character. No difficulty, we understood, is found here, as we had heard to be the case at St. Cyr, in enforcing the fullest attention to the lectures of the civilian professors; each is respected according to his knowledge of the subject, and it would be thought as absurd for a military professor to undertake a non-professional subject, as *vice versâ*.

The method of working is that so commonly followed in the

Prussian universities of listening to numerous lectures, and taking copious notes upon them. Nearly five hours daily, from eight in the morning till one, are often continuously occupied in this manner; for although only twenty hours of attendance are absolutely exacted weekly (an amount which to our own students would seem more than ample) ten more are said to be necessary to enable an officer to do any justice to the various subjects of which he is expected to show some knowledge at his examinations.

These lectures are usually read aloud; there is no questioning and answering. The student, after five morning hours, must spend at least five or six more in copying them out, or in writing an essay on the subject of some of the lectures. Of these one is given about every three weeks, but only on military subjects. They are carefully corrected and sent back to the student with the notes of his teacher, and their merit influences the final estimate of his whole work.

Besides this daily work, the examinations are at once a stimulus and a means of testing proficiency. These occur every three months, but the yearly ones are the most important. They are entirely upon paper. In the quarterly ones the papers are only given for two hours at a time daily, and take the place of two common lectures; in the other examinations they are daily for four or five hours. They are entirely essays upon the numerous subjects lectured on in the school, History of War, Philosophy, Tactics. &c.

Perhaps there is no better way of giving an idea of the mode of studying than by a statement of some of the subjects of these essays. They have been supplied to us by the kindness of Lieutenant Berger, of the 28th Infantry, from whom we have received much valuable information on the subject.

General Essays.

On Tactics:—1. A Prussian Division, added to which is,—
1 Regiment of Infantry,
1 twelve pounder Battery,
1 Cavalry Regiment,
is in retreat from Goldberg to Jauer (in Silesia.) The enemy is following. A position is to be taken up to stop his advance, whatever his numbers may be.
A map of the position being given:—
(*a.*) Describe the position.
(*b.*) Draw up the troops.
(*c.*) Write an explanatory criticism.
(To be worked at home in two days.)

Three Corps d'Armée march against Berlin from different points. The army in Berlin is ordered to meet them. (To be done in five hours.)

Permanent Fortification. For what purpose are the fortifications in the main ditch intended, and how are they to be constructed? (Five hours.)

Military Geography. The Saxon land between the Elbe and Saale, and its influence upon the operations of war in North and South Germany. (Five hours.)

Criticism on the organization of the French Battalion. (At home in one day.)

Examination Essays, Staff School.—Military History, Tactics and Administration.

1. In what respects did the earlier form of military art, strategetically and tactically, favor defensive wars *generally*, and in particular assist Frederick II. in the Seven Years' War? (Two hours.)
2. The duties of the Staff in time of peace. (Two hours.)
3. Position of Landwehr Officers on and off duty. (Two hours.)
4. What is the value of the Cavalry formation *en échelon*, with particular reference to the Austrian mode? (Two hours.)
5. Is only one sort of Infantry necessary, or is Light Infantry essential? (Two hours.)
6. How may the mobilizing of an Army be best expedited? (Five hours.)
7. Describe the different sorts of fieldworks particularly used in war. (Two hours.)
8. How is the Artillery of a Corps d'Armée to be used in the different emergencies of battle? (Five hours.)

Literary and Scientific.

1. The Geological characteristics of the country between the Carpathian Mountains and the Vistula on one side, and the Valdai Mountains and the Dnieper on the other. (Two hours.)
2. By what political conjunctures was the power and influence of England peculiarly advanced in the 18th century? (Five hours.)
3. On the magnetic effects of the electric stream. (Two hours.)
4. Characteristics of Greek literature, and its chief authors in the time of the Peloponnesian War. (Two hours.)

The knowledge required is seen in the account of the Staff School, (p. 395) and in the list of the Lectures given above. Besides military jects, it includes a very full course of Ancient and Modern History, an addition to the History of War (which last alone occupies seven hours weekly for the last year,) a good deal of Logic and Philosophy of Art and Literature, and of Political Economy. Some of these lectures have probably been introduced from the school, having a double object, that of giving a diplomatic as well as a military education. This was the original idea of Frederick the Great, who, in all his plans of military teaching, laid a great stress on the general literature which he himself valued so highly. This diffusive study is a strong contrast to the principle of "little, but well," and to the constant practical exercises in the laboratories insisted on by the early teachers of the Polytechnic School in France.

The following is the plan of the lectures for the three years. Twenty lectures a week are the minimum:—

Course of First Year.

Obligatory.		For Choice.	
Tactics,	4 hours.	Universal History,	4 hours.
Artillery,	3 "	Universal Geography,	3 "
Field Fortification,	2 "	Physical Geography,	4 "
Military and Political Administration and Economy,	2 "		10 hours.
Mathematics, Pure and Mixed,	6 "		
	17 hours.	Total, 27 hours.	

Course of Second Year

Obligatory.		For Choice.	
Tactics,	4 hours.	Universal History,	4 hours.
Permanent Fortification,	2 "	Mathematics,	6 "
Special Geography and Geology,	4 "	Logic,	4 "
		Physics,	4 "
		Lectures on Horses,	2 "
	10 hours.	Total, 30 hours.	20 hours.

Course of Third Year.

Obligatory.		For Choice	
History of War,	7 hours.	General History of Literature,	4 hours.
Staff Duty,	3 "	Mathematics,	6 "
Art of Sieges,	2 "	Higher Geodesy,	3 "
Military Jurisprudence,	1 "	Chemistry,	4 "
	13 hours.		17 hours.
		Total, 30 hours.*	

It will be seen that the above course is entirely theoretical; no practical work (as in France) relieves the sedentary labor of ten

* Lectures each week in the War School, Prussia.

War School.	First Year.	Second Year.	Third Year.
Mathematics, Pure,	3	3	3
" Mixed,	2	3	3
H. Geodesy,	..	..	3
Physical Geography,	2	..	..
General "	4	..	..
Special "	..	4	..
Universal History,	4	4	..
General History of Literature,	..	..	4
Logic,	..	4	..
Physics,	..	4	..
Chemistry,	..	..	4
Veterinary Art,	..	2	.
Tactics,	4	4	.
Artillery,	3	..	.
Fortification, Field,	2	..	..
" Permanent,	..	2	..
" Sieges,	..	..	2
Military Administration,	2	..	..
History of War,	..	..	7
Staff Duty,	..	..	2
Military Law,	..	..	1
French,	6	6	6
Russian,	4	4	4
Total,	37	40	40

It would be impossible to enter on a detailed criticism either of these lectures or of the essays mentioned in the note above which evidently imply great study. We invite a comparison with the French plan, which we have given elsewhere, but the difference of age must be taken into account. The mathematical course at this school is,—

1st year. Plane and Spherical Trigonometry, Quadratic Equations, involving several unknown quantities, the Binomial Theorem, and the Elements of Analytical and Solid Geometry.

2d year. Analytical Geometry and the Differential and Intregal Calculus.

3d year. Mechanics, Statics, Dynamics, Projectiles, and slight Applications.

Only the first year is obligatory.

hours daily for more than eight months of the year. But as soon as the first year's course is ended, all the officers who are supposed to know drawing before coming to the school, are sent into the country for three weeks to practice military drawing and surveying; and those of the third year go through (also for the same period) a similar course of staff duty. These last are sent under the direction of the officer who is Professor of Staff Duty at the School; each student officer gets his separate orders, and they meet and are told off every morning for their day's work, reconnoitering fortresses, surveying the frontiers between Austria and Prussia, &c., &c. During the remaining three summer months the students are sent in successive classes to those arms of the service which are not their own, and after the usual military exercises are completed they must bring back with them a certificate of proficiency from the commanding officer. This amount of time was spoken of as being too little.

If we are surprised at not finding a greater amount of practical work included amongst the labors of the school, we must remember that it is chiefly postponed to a later period of the officer's career, when the probability of his being required to use it on the staff is greater. This is when he has gained his place in the Topographical Department, and is working there upon trial to test his fitness for the actual staff. He is then employed during winter in working on the Theory of War, and during summer in military surveying and drawing.

Such is the method and extent of the officer's work at the Staff School; a few more words are needed on the character of his examinations, which here as everywhere else must greatly influence the character of the work.

There are no less than nine examinations during the three years, one for every three months, but the final one at the end of each year is the more important, as a sort of summing up of the year's work. In marking for this the merit of the essays done at home is taken into account. The result in each branch of work and on every examination is entered by the several professors in a book kept at the directory, and the pupils have a right to inspect the report of their own work. The net result of his own three years' work is also sent to the officer after leaving the school through the authorities of his regiment. The certificate of this contains the criticism on each branch of his work in detail.

The subjects given for essays will show the nature of the chief examinations (*i. e.* those at the end of each year;) four or five hours

is the time generally allowed to a difficult subject, the examination stretching over a number of days, in proportion to the subjects taken up. The pupil may bring in his notes of lectures, on which extraordinary care is bestowed, and which must contain everything that can be said on the subject. Much value is said to be attached to the rapidity with which an essay is worked, as showing a quality valuable in an officer. There is, as we have observed, no *vivâ voce* of any kind in this School. Some competition exists in the Staff School, (and it is almost the only Prussian school where we find it,) for the knowledge that only eight or ten out of the forty pupils can obtain the Topographical Department, and only two out of these eight or ten, the staff, acts as a competitive stimulus. We must add, however, that although a minute account of the *positive* merits of the pupils is drawn up and sent to them at the end of their career, they have no means of ascertaining their *relative* positions; and this may always leave room for doubt, whether the places in the Typographical Department and on the Staff are strictly given by merit, or whether patronage does not here step in. Another ambiguity may be remarked in the fact that the relative importance of the subjects of study is not known. It may of course be surmised, that a knowledge of the Peloponnesian War is not marked so highly as that of the Seven Years' War; but any indefiniteness as to what is or what is not important, will generally lead to an attempt to know something *of all* the subjects mentioned, and it would undoubtedly be better to affix its definite value to every subject. It would prevent what seem to us valid objections to the present system of the Staff School, the attempt to crowd in too many subjects, instead of mastering thoroughly a few.

The final examination having been completed in June, the student goes through the three weeks of staff duty we have described, and finishes his last three summer months in that branch of the army in which he has not yet served. He then returns to his regiment, where he receives the certificate of his three years' work. But no list is published of the order of merit in which the officers stand. If the certificate is satisfactory, he forwards it to the Chief of the Prussian Staff, with a request to be employed in the Topographical Department of the Staff. If this is granted, he receives an order to join it in about two years, *i. e.* about nine or ten years after first entering the service.

About eight officers are yearly sent to the Topographical Department, and serve there for two or three years, surveying and drawing in summer, working at military science in the winter. The

correction of the Topographical Map of Prussia is in their hands. Finally, two out of these are selected for the Staff; the remainder return to their regiments, to become adjutants or to teach in the Division Schools.

The most immediate advantage of being in the staff corps is promotion to a captaincy at any age, which, considering the extreme slowness of promotion in Prussia, may be termed an early one. This is generally gained within two or three years after joining the corps, *i. e.* at thirty-three or thirty-four. In other corps hardly any one has a chance of becoming captain till after forty.

We may add, that the number of officers in the Topographical Department is about forty, on the staff itself sixty-four. No one belonging to the staff is below the rank of captain, or above that of colonel. Every general of division has one officer of the staff attached to him, and two adjutants, the first nominated by the chief of the staff, the two last by the king, and these two belong rather to the officer than to the general. They are not removable with him. The adjutants are not officers of the staff, though they are often chosen from amongst those who have been at the Staff School. They are nominated by the king upon reports sent into him by the generals of division, and the appointment is not considered a great prize, as it implies neither extra pay, promotion, nor permanency; the adjutants are promoted in the usual course, and then, upon promotion, return to their regiments. The adjutants of battalions and regiments are appointed, like our own, by the officers commanding. The name of aide-de-camp does not exist in the Prussian service, but that of adjutant is used in its place.

VII. ELEMENTARY MILITARY SCHOOLS FOR NON-COMMISSIONED OFFICERS.

1. MILITARY ORPHAN-HOUSES.

There are three Military Orphan-Houses in Prussia for the children of soldiers, two for boys, one at Potsdam, and the other at Annaburg, and one for girls at Pretzch. Although intended for orphans, they receive children whose parents are too poor to provide for them. They receive a good elementary education and are brought up for trades, and can make their selection between a civil and a military career. The English Commissioners report that they found 800 pupils in the Orphan-House at Potsdam, of whom 200 were under the charge of female teachers; 520 were in the senior department, including thirty-six in the music class, who will go into the Regimental Bands, and about twenty who formed a separate military class, who would probably enter the Artillery School.

The School at Annaburg, and the subsidiary Girls' School at Pretzsch, are both Protestant in character; no religious teaching is supplied for Roman Catholics. Roman Catholic boys are all sent to Potsdam, and Roman Catholic girls are provided for in ordinary schools, and in private families, and payment made on their behalf out of the funds of the institution.

Dr. Bache in his "*Report on Education in Europe*," gives the following account of these institutions.

Military Orphan-House at Potsdam.

This institution was founded in 1724, by Frederick William the First of Prussia. The reputation of Franke's Foundations induced this monarch to rival the benevolence of the clergyman, and to establish on a scale proportioned to his greater means, a house for the education of the orphans of his soldiers. While, however, the recipients of Franke's bounty are free to choose their career in after life, and only so far bound to the institution, as a sense of gratitude may prompt, the youth who passes through the Military Orphan-house of Potsdam, must enter the military service for twelve years. Three of these, indeed, are the term of service of every citizen, and I believe the three years in the non-commissioned officers' school are now counted as part of the twelve, and thus the actual number of extra years of service is reduced to six. The institution began with one hundred and seventy-nine children, both girls and boys being received; this arrangement continued until a few years since, when the girls' school was removed from Potsdam, and the establishment at present is for male pupils only. There are between three and four hundred in the elementary or boys' department. In the early history of the orphan-house two attempts are recorded to introduce manual labor, as a profitable speculation; neither of which appears, however, to have succeeded. The first of these, the manufacture of Brabant lace, was introduced in 1743, and after various modifications of the mode of applying the labor of the children, it was finally abandoned in 1795. In 1744, the culture of silk was introduced extensively throughout the kingdom, and especially enjoined at the orphan-houses; but this attempt was not more successful in the end than the other, and the culture is not kept up in this institution.

The present spacious buildings were chiefly constructed under the reign of the founder and of Frederick the Great. Additions have, however, been made from time to time since, and the whole plan is hardly yet completed. The institution may be considered as divided into three departments or schools; an elementary school, (called the Boys' House, *das Knabenhaus*,) a trade school, and a music school. The buildings for the elementary school are erected about a spacious court, which serves as an exercising and play-ground. On the ground floor are the refectory, in which all the youth from the different schools composing the institution, meet three times a day, and the study and play-rooms, lavatory, &c. The study-rooms form a long range, and when the doors of communication are opened, one teacher can superintend the whole of the classes. The school-rooms are on the first and second floors, and are calculated for divisions of forty boys each. There are six dormitories, furnished with wooden or iron bedsteads, the latter having been more recently introduced and found to

answer well. The bedding consists of a straw bed beneath, and a mattress of hair above. Each dormitory is superintended by a teacher, who sleeps at one end of it. There are also dwelling-rooms for the teachers, officers, &c., and in the court a very large wash-house, with a drying-room above it.

The buildings occupied by the trade and music schools are separated by a street from the others, and with the dwellings of the officers, a room for gymnastic exercises, and musical practice, and the workshops, form a second immense series of structures. The infirmary is near to them, and is under a separate direction; subordinate, however, to the general executive body. It is divided into rooms assigned to patients suffering from different complaints. A schoolmaster gives instruction to the convalescent. The arrangements in the dormitories of the trades' school, are similar to those used in the army, and the superintendence and discipline are strictly military.

The part of the building occupied by the music school, contains separate rooms for practicing by individuals, class-rooms, and dormitories. There are rooms in the main pile for the meetings of teachers, for a small library, &c.

The executive board of this school depends partly on the ministry of war, and partly on that of public instruction; the former, however, is the controlling authority. Under this board is the military superintendent, or director, to whom the chaplain, the secretaries, the economist, the military superintendent of the day, the teachers, commandants of companies, the inspectors of the trades' and music school, and other officers, are directly responsible. The clergyman is the superintendent of the elementary school, and has a general charge of all the intellectual and religious instruction.

The orphan children of soldiers are received for maintenance, at any age, by the authorities of the establishment, but if under six years, are boarded with their friends or others until six, and then admitted into the house at Potsdam; they remain there until fourteen or fifteen years of age, and, if of sound constitution, are transferred to the trade, or to the music school, where they remain four years, and whence they pass, if their conduct has been good, to the school for non-commissioned officers. I have never seen a body of young men all so well physically developed as the pupils of the trade school, a result produced by constant attention to their education on this point. Children who are not healthy, or who have failed in the elementary school, are apprenticed at fourteen, and the institution ceases to have the charge of them.

In the *Elementary School*, the usual branches taught in the common schools of Prussia are pursued, including reading, writing, arithmetic, the German language, geography, drawing, religious instruction, and a little natural history. The boys are divided into four classes, according to their proficiency, and all the classes below the first are subdivided into two sections, each being under the charge of a teacher, and having a separate recitation room. These sections contain about forty pupils each. A monitor of order from among the pupils, has charge of a section on entering and leaving the school-room, and render such service as the master requires during the lesson; he is assisted by one of the class in the distribution of the books, slates, and other implements of instruction. The teachers keep each a roll, upon which the character of the recitation and conduct of the pupils is entered, and which is examined weekly by the chaplain, and submitted to the board of teachers at their meetings. No youth, who is below a certain grade upon this roll, is permitted to enter the trades' school. There are about five hours of instruction on four days of the week, and

about twenty-three in the whole week. The holidays are, a week at Easter, four days at Michaelmas, a fortnight in the latter half of July, and from the twenty-third of December, to the second of January. For those who have no friends to go to, the Christmas festivities are kept up in the school, as in the private families of the country.

The board of teachers meet once every fortnight, and the director, or his substitute, or the chaplain, presides. At their meetings, all matters relating to instruction and discipline are discussed.

The form of the discipline of the school is military, but a spirit of mildness tempers it, suiting it to the age of the pupils. The boys, in general, are divided into four companies, each of which has a commandant, (a non-commissioned officer of the highest grade,) who has charge of the instruction in military exercises, and ranks with the teachers of the school. These companies form a battalion, and are drilled without arms, and inspected by the director, or an officer appointed by him. In turn the commandants of companies, acting as officers of the day, have general charge of the military and police duties. Two of the teachers, also, in turn, act as inspectors of the day, and have the general superintendence of the pupils in study and recreation hours, in the duties of personal police, at meals, and in the dormitories, relieving each other at different parts of the day. They are co-ordinate in authority with the officer of the day, and he is expected to relieve and aid them in the maintenance of order. These officers report immediately to the director.

The four companies are subdivided into sections of eleven, over each of which one of the boys is placed, with the title of overseer, or corporal, and he is responsible for the good order of his section, and may be assisted in his duties by one chosen from it. From among these corporals one is selected for the general control and superintendence of the others, and marches the company to the lavatory, to meals, to the dormitory, &c., being responsible for them whenever they are collected as a company. The boys composing a section are placed at meals upon the same side of the table with the corporal who has charge of them. The younger pupils do not join these companies at once, but are kept together in a division which is under female superintendence, has a separate overseer, and is under different regulations as to rising, going to bed, and other particulars of discipline and police from the elder pupils.

All the duties of domestic and personal police, and some of those of domestic economy, are performed by the boys enrolled in the four companies. They clean their own shoes, brush their own clothes, attend to the police of the different parts of the building, serve the meals, and make their beds. That the various duties may be attended to in an orderly way, there are, besides those already spoken of, special overseers appointed among the pupils, who have general charge of them while engaged in certain duties, and of particular localities. Thus there is an overseer of the room where the clothes and shoes are kept, who has charge of the exchange of the Sunday for week day dress, and vice versâ; an overseer of the room where the shoes are brushed and blacked; an overseer of the lavatory; four superintendents of cleanliness, who direct the pupils while washing and combing their hair; one of hair cutting; two of serving the table, who have charge of a detail of thirty pupils, who serve and clear the tables and clean the knives and forks; one, of the manual labor classes; one, of the sick in the hospital; one, of those who are unwell, and must report to the physician; one, of the lights; one, to prevent the passing of bounds; one of

the pupils who sing the liturgy in the church; one to conduct the pupils, whose shoes require repairs, to the shoemaker; besides, those for the classes and the younger boys, already mentioned, and a few others. I make this enumeration in order to show the minuteness of the arrangements for police and discipline, and the extent to which they are conducted by the pupils themselves. The selections for appointments are made by the teachers and officers, and submitted to the chaplain and director for their approbation. A part of the pupils employed as superintendents recieve small pecuniary allowances, and all enjoy many privileges.

Some of the pupils, who are found to have a taste for music, receive special lessons, and are employed, when sufficiently proficient, to give the signals for the different duties of the day. Eight pupils are thus selected to be taught the bugle and fife, and twelve the drum.

In regard to conduct, the pupils are divided into four grades, according to the reports of the teachers and officers, a revision of the classification taking place every quarter, and the director having, in the meantime, the power to displace a pupil in a case of emergency. The first class grade is composed of pupils distinguished for unvarying good conduct, and on holidays its members are allowed to leave the orphan-house alone to make small purchases at discretion, and are neither subject to corporal punishment nor to the stoppage of their meals. The second class is composed also of meritorious pupils, but of a lower grade of conduct than the first; they are permitted to leave the school sometimes, but not so often as the others, and are generally under supervision. From these two grades only, the superintendents or overseers are taken. Pupils of the third grade stand between those who are decidedly good or bad, and are treated accordingly. They are the last who are permitted to pass from the elementary to the trades' school, on completing their course in the former. Those of the fourth, or lowest grade, are kept constantly under supervision, have no allowances, no leaves of absence, are separated, when possible, from the rest of the pupils, and are even punished by an inferior diet.

The health of the pupils is promoted by frequent bodily exercise, and, when the weather permits, in the open air. Thus they have regular gymnastic exercises four times a week, are drilled by companies four times, and by battalion twice a week, take frequent walks, and in summer, bathe every day. The regular manual labor in this department of the school is confined to knitting and tailoring. The gymnastic exercises are conducted by two teachers, each taking charge of one of the companies, of which two attend the lesson at the same time, and assisted by pupils selected from among the most proficient in the exercises. There are two swimming lessons given to each company, in summer, every week. In the ordinary division of the day, in summer, between two and three hours are allowed for manual labor, the same for recreation, two hours for exercise, and nearly eight for sleep.

Their clothing is a neat uniform jacket of blue cloth, of a military fashion, gray or white pantaloons for the winter, and a brown linen jacket and white linen pantaloons for the summer, and their officers are distinguished by badges similar to those worn in service. The diet is generous, and, besides the three meals, bread is served as a luncheon in the morning and afternoon intervals.

An opportunity is given to those who are to pass into the trades' school, to ascertain the trade which they may wish to follow, by a trial during the last year of the elementary course.

The order of the day, with merely slight variations during four days of the week, in summer, is as follows:—The pupils rise at a quarter before five o'clock, and proceed by companies to the lavatory, two companies occupying it at once and alternating, the other two being, meanwhile, engaged in cleaning their shoes. Wash and comb their hair. At half past five the boys detailed to serve the meals proceed to the refectory under their two superintendents. At a quarter before six the bugle sounds, and the companies assemble, by sections, in the court-yard. Morning prayers and breakfast. Those who are slightly sick report to the physician. At a quarter before seven, the boys assemble according to classes, and at seven are marched to the school-rooms. At a quarter before nine a luncheon of bread is served out to them. School closes at eleven, and the pupils are free for three-quarters of an hour. Dinner at about a quarter before twelve. The pupils brush their clothes, and are inspected by the officer of the day. From a quarter past one to half-past two, review the morning lessons in school. From a quarter to three until five, are occupied with manual labor in the work-rooms. Part of the pupils receive instruction in music, and the first and second classes in drawing; a stated number take a swimming lesson; the drummers, fifers, and buglers also have a lesson. A luncheon of bread is distributed. One of the companies is at drill, one at gymnastics, and the other pupils bathing or walking until seven. Evening prayers in the refectory, and supper. Wash, and have recreation until nine, when they retire. The younger pupils retire at half-past eight.

In winter, the different occupations of the day are each one hour later than in summer, until half-past two, when the hour of review of the lessons is omitted, and the exercises, as far as appropriate to the season, follow in the same order as in summer, until half-past five, at which hour the pupils go to the school-room, and remain until a quarter before seven.

On Wednesday and Saturday, an hour is devoted to religious instruction, the other lessons being omitted, except the physical exercises on Wednesday. Stated days and periods of the day are assigned for the exchange of the week-day clothes for those of Sunday, for taking clothes or shoes requiring repairs to the tailor or shoemaker of the establishment, for hair-cutting and combing, for washing the neck and shoulders, the feet, and for other minute matters.

The object of the *Trade School*, is, in part, to economize the funds of the institution, by making within its walls articles of clothing required for the pupils, but more to secure the acquisition, not only of general mechanical dexterity, but of a trade, which may serve to increase their emoluments when they enter the military service. There are, at present, one hundred and four pupils.

In order to pass into the trades' school from the elementary division, the pupil must have reached at least the second class, have been above the fourth grade in conduct, be between fourteen and fifteen years of age, and of a bodily constitution fitting him for the military service. The course lasts three years. The school has a special inspector, or superintendent, who is responsible to the director of the whole institution, or, in fact, to his substitute.

The different trades now taught here are those of blacksmiths, saddlers, tailors, shoemakers, and lithographers. The last named has but seven pupils admissible to its school, and the next to the last forty-four. These numbers depend upon the demand for the occupation subsequent to leaving the establishment, the space required for the operations of the trade, the difficulty of teaching, &c. As each pupil is in general permitted, on advising with the inspector,

to choose his employment, it sometimes happens that boys are sent into the town to learn a trade not taught in the school. Changes of occupation are very rare, but are sometimes permitted. The blacksmiths are principally engaged in the repairs of arms, the saddlers make the caps and accoutrements, &c., used in the house, the tailors all the uniforms, the shoemakers supply not only this orphan-house, but that of the girls with shoes, and the lithographers are occupied in copying forms for the school or war department, manuals, &c. They work about seven hours a day, under a master-workman from the town.

An hour of each day is spent in gymnastic or military exercises in the open air in summer, and in winter in the large room before spoken of. The military exercises, besides the ordinary ones, comprise some which are peculiar to the Prussian service. The usual exercises of gymnastics are introduced, omitting any which seem to have a tendency towards the tricks of the mountebank. For instruction in these exercises, the whole school is divided into two parts, and each again into squads, so that the teacher need have but twelve to fourteen under his charge. Non-commissioned officers are the under teachers, and in turn are superintended by higher teachers, and by an inspector.

There can be no doubt that to these well regulated and perseveringly continued exercises it is, in great part, due that the physical development of these youths is, on the average, so perfect. Judicious recreation, a proper diet and clothing, great cleanliness, a proper number of hours of work, of instruction and sleep, no doubt, are necessary, each and all in their degree, but great influence must be besides allowed to the gymnastic exercises.

The pupils have two hours of instruction during the day, intended to keep up their knowledge of the branches taught in the elementary school, rather than to teach new ones. Military drawing is, however, added.

When not in the shops, nor in school, nor at exercise, they are superintended by non-commissioned officers. The discipline in this school is military in spirit, as well as in details.

Those pupils who have manifested a decided musical talent in the lower school, are here instructed thoroughly in the theory and practice of music. The object is to supply musicians to the regimental bands. These pupils have a separate superintendence from those of the other schools, and different hours of exercise and duty. They keep up the knowledge acquired in the elementary school, as is done in the trades' school.

Military Orphan-House at Annaburg.

The following plan of instruction was prepared by Dr Harnisch, one of the most distinguished teachers of Prussia, formerly Principal of the Teachers Seminary at Weissenfels.

In order to rise to the place of a non-commissioned officer, the pupil must have gone through the lowest classes of the Upper School, where there are the following studies:—

Religious instruction, arithmetic, singing, the German language, calligraphy, geography and history, algebra, geometry, trigonometry, and drawing.

The courses in the different branches are arranged as follows:—

FIRST. *Religious Instruction.*

LOWER SCHOOL.

Class VII. Bible stories, psalms and hymns, appropriate to the season. Four hours per week.
Class VI. Histories from the Old and New Testament, portions of the history of the Christian church, catechism. Four hours per week.
Class V. Reading and explanation of the Bible, and of its arrangement. The gospel and

historical works are selected, and the history is connected with the geography of the Holy Land. Catechism. Five hours.
Class IV. Doctrines of the Lutheran church, taught by Luther's catechism. Five hours.

UPPER SCHOOL.

Class III. Moral instruction, duties to God and man. Three hours.
Class II. Reading the Bible with comments, the pupils making abstracts. Three hours.
Class I. (Two years.) The first year a repetition of Luther's catechism. The second, a history of the Christian dispensation. Three hours.
Every class commits verses from the Bible to memory.

SECOND. *Arithmetic.* Mental and written arithmetic are taught together, that the readiness afforded by the one, and the accuracy of the other, may both be cultivated.

LOWER SCHOOL.

Class VII. The four ground rules, with three places of figures mentally. Application to questions in weights and measures. Three hours.
Class VI. The same rules extended. Three hours.
Class V. Fractions, with applications to weights and measures. Three hours.
Class IV. Proportions. Three hours.

UPPER SCHOOL.

Class III. The applications of proportions to questions of weight, strength, value, time, and general quantity. Two hours.
Class II. Exercises in practical algebra. Two hours.
Class I. Review of the course. First year, practical operations. Second, theory of arithmetrical processes. Two hours.

THIRD. *Vocal Music.*

LOWER SCHOOL.

Classes VII & VI. Practice of songs, adapted to youth of a cheerful, serious, military, or religious cast, with one part. Two hours.
Classes V & IV. Choral and other songs, with the different parts. Elements of music. Two hours.

UPPER SCHOOL.

Classes III, II, & I. More difficult choral pieces. Theoretical instruction continued. One hour. There is, besides, instruction given to a select choir, intended to conduct the vocal exercises of the church.

FOURTH. *Reading* In the lower classes, a readiness in reading, and in the higher, the style of reading, is attended to especially. Pieces learned previously, by heart, are recited.

LOWER SCHOOL.

Class VII. A good pronunciation, and some facility in reading. Six hours.
Class VI. Readiness in reading, and repeating the substance of what has been read. Familiar illustrations. Five hours.
Class V. Reading some work in reference to knowledge useful in common life. Four hours.
Class IV. Reading, with attention to emphasis. Four hours.

UPPER SCHOOL.

Class III. Reading the Bible and sacred melodies, with the view to correct reading in this kind of composition. Two hours.
Class II. Reading various selected works, in and out of the class.
Class I. Reading continued, and recitations from works previously read.

FIFTH. *Orthography and Writing.* These may be taught together in the same way as mental and written arithmetic; the teacher is, however, at liberty to follow his own method.

LOWER SCHOOL.

Class VII. Copying on slates from the blackboard. Four hours.
Class VI. Copying on paper, from the board, and from books. Four hours.
Class V. Writing from copy-slips, from books, or from dictation. (Practice in spelling and writing.) Four hours.
Class IV. Similar exercises continued. Four hours.

UPPER SCHOOL.

Class III. Copying useful papers, such as registers, accounts, contracts, &c. Two hours.
Class II. Calligraphy, with Roman as well as German letters; practice in orthography; reading of letters and documents in various handwritings. Two hours.
Class I. Copying papers relating to the management of the institution, as a practical introduction to business. One hour.

SIXTH. *Useful knowledge taught by induction*

LOWER SCHOOL.

Class VII. The pupils give their ideas, verbally, of surrounding objects of the most simple kind, of the commonest productions of nature and art. Conversations relating to them. Drawing the most simple mathematical figures on the slate. Three hours.
Class VI. Descriptions of animals and plants, the former in the winter, the latter in the summer term. Written remarks on these, serving to afford exercise in the formation of phrases and in orthography. Four hours.

Class V. The most essential parts of physics and natural history, the pupils taking notes of the lessons. Four hours.
Class IV. Compositions on various subjects. Letters relating to civil and military affairs. Four hours.

UPPER SCHOOL.

Class III. History of Prussia, and drawing of maps. Four hours.
Class II. General geography, particularly that of Europe. Passing from physical to political geography. Civil geography in connection with the former. Five hours.
Class I. Universal history. One year is devoted to ancient and one to modern history. Selections are made of the more important parts of history. Five hours.
The remaining studies only belong to the higher school.

SEVENTH. *German grammar and style.*

UPPER SCHOOL.

Class III. Logical and grammatical instruction of the German language taught.
Class II. Idiom of the language. Compositions on military subjects, with especial reference to correctness of grammar.
Class I. Acquaintance with the best writers. Exercises of composition on subjects taken from history.

EIGHTH. *Geometry.*

UPPER SCHOOL.

Class III. Teaching the names and properties of mathematical figures by induction, in connection with drawing.
Class II. Equations, with application to problems of common life.
Class I. Elements of trigonometry.

NINTH. *Drawing.*

UPPER SCHOOL.

Class III. Drawings from common objects, varying the positions, &c.
Class II. Copying flowers, or drawings of implements.
Class I. Architectural drawing with instruments, drawings of furniture, &c.

Dr. Bache makes the following remarks on the above plan:

I have allowed myself to present this extended programme, because it conveys, in as brief a compass as possible, excellent ideas of the succession of courses in an elementary school, and in a technical or trade school, for such the higher school must be considered. It should be remembered that the main purpose is the preparation of youth for the military service, and hence that the wants of the service are especially consulted. Another fact must be remembered, namely, that this is a Lutheran school, and therefore the religious instruction is adapted to the particular views of that church. The course of morals of the third class, I must say, however, seems to me out of its place, for although our duties to God and our neighbor are of course best learned from his Word, yet their inculcation by precept and example can not commence too early.

In the arithmetical course, the union of mental and written arithmetic is absolutely essential. The gradation appears to me good, and the application to questions of common life gives a zest to such studies, attainable in no other way. The theory of arithmetical processes, however, should accompany or follow more nearly their practical acquisition. Indeed, if they are taught as they ought to be, by induction, the theory goes with the practice.

If the youth at Annaburg take the same pleasure in the exercises of song, from the elements to the completion of the musical course, as those of the school* actually superintended by the author of this project, the success will be complete.

The connection of orthography and writing, especially if combined with early reading, is natural.

The exercises of induction, which in the lower classes are well drawn out, deviate from the appropriate track in the fourth class, and in the geographical and historical courses do not return to it. The system in both these branches is rather synthetical than inductive. There is a great temptation to break away from this method, into that of giving positive instruction, from the apparently greater rapidity of progress of the pupil; some teachers have abandoned it altogether, as too slow, though ultimately to their cost, as appeared to me in cases where I had an opportunity of comparing the results.

The writing is preceded by an introductory course of drawing, which might

* Seminary for Teachers at Weissenfels.

with excellent effect be so extended as to branch out into complete courses of drawing and writing.

As this plan results from an extended experience, the number of hours of instruction, per week, necessary to secure the results, is an important datum, and as such I have retained it, whenever it was inserted in the original programme.

II. THE SCHOOL DIVISION OR NON-COMMISSIONED OFFICERS' SCHOOL.

A military school of a somewhat peculiar character for training up young men for the duties of non-commissioned or *under* officers exist at Potsdam, and is known as the School Division.

The rules of the Prussian Military system, which require only three years absolute service in the standing army in time of peace, evidently entail a great practical difficulty in this respect. The soldiers, as a rule, prefer to quit the service at the end of their three years' time, and require great inducements to persuade them to remain. As one inducement, the state has declared that twelve years' service gives a non-commissioned officer a formal claim to civil employment; as, for example, on the railways or in the custom-houses. Their pay also as non-commissioned officers goes on increasing according to the length of their service; and it was stated to be the usual practice not to advance soldiers to be non-commissioned officers until they had signed an undertaking to serve for a longer period than could be exacted of them otherwise.

A further means of supplying the want has been sought, and appears to have been found in the School Division. The circumstances of its origin have placed this establishment in immediate connection with the Corps of Guards, to which, in a military sense, they belong, at whose head-quarters, the town of Potsdam, their buildings are situated, and whose garrison duty in the town they occasionally undertake.

At its first commencement the pupils chiefly came in drafts from the Military Orphan-Houses. But the applications from the country in general have been so numerous that this practice has been, it is said, abandoned, and a higher class of admissions has been attempted. The Commander of the Battalion of *Landwehr* for the Circle (*Kreis*) receives all applications in that Circle; he sees that the candidate is examined on the spot, in reading, writing, and cyphering; and forwards the name, height, age, and other particulars (the *Nationale*) to the authorities. The decision is said to be mostly made by the candidate's height, and his medical certificate, and to be rather a difficult matter. Only one-third of the applications are successful. A new boy had just presented himself with

his father at the time of our visit; both son and father were well dressed, and apparently belonged to the middle rather than the lower classes. There seems every reason to be satisfied with the amount of acceptance with the country which the school had begun to receive.

The age of admission is from seventeen to twenty, and the youth on entering the school takes a military engagement to give two years of service in the standing army for each year of his maintenance at the school, in addition of course to those three years of military service to which every Prussian is bound, but with the privilege of counting as military service the period spent at the school.

The usual school course is one of three years, and his engagement is thus for a term of nine years; that is, deducting three spent at the school, six years' time with the troops.

The School Division is 496 strong; there are four companies of 124 men. The whole body is commanded by a captain, or major, who has an adjutant. To each company are attached four officers and fourteen non-commissioned officers; the latter teach in the two first years, the former in the third. The school course begins on the 1st of October; the afternoons of three days in each week are employed in ordinary school instruction, but the remainder of their time in winter and their whole time in summer is devoted to military training. The school instruction is not carried beyond reading, writing, and arithmetic up to the rule of three; geography, drawing skeleton maps, and copying, and learning the significance of military representations of ground. Some very respectable specimens of their skill in copying maps were produced; it appeared to be a favorite exercise.

About 150 are admitted yearly, an extra number being taken to supply possible vacancies; about 130 yearly are drafted into the army, six usually as *under* officers at once, forty at least with certificates of being qualified to receive the grade in a short time; and the whole number who go out have generally obtained their appointment before twelve months are completed. The highest number that may go out at once as under (or non-commissioned) officers is twelve; three for each company. Many, however, have latterly, it is said, become so within six weeks after their leaving.

Where the young men are strong and full-grown, they are allowed to join the army at the end of two years; their whole service (two years for each at the school) being therefore reduced to six years.

Young men, on the other hand, who show no disposition or like-

lihood to turn out good *under* officers, are sent off to complete the usual time as privates.

The proportion of non-commissioned officers in the standing army who are taken from the School Division was not easy to ascertain. It differs extremely in different regiments. In one, it was stated that out of the ordinary complement of 180, fifty came from hence. On the other hand, it was asserted that the general proportion was not more than one in forty. A certain number have obtained commissions; but no prospect of such promotion appears to be held out, and any tendency to carry forward the studies with a view to it is discouraged and checked.

The buildings, in the outskirts of Potsdam, are large, new, and handsome, forming three sides of a spacious court or imperfect quadrangle. The dining-rooms are used also as exercise-rooms, and it was made a point to let us see a portion of the pupils go through their gymnastics and exercises; and more particularly their sword and bayonet exercise. Twenty or thirty young men, very healthy and strong-looking, went through the latter exercise in two lines; after which came a single combat with the bayonet, all under the direction of an officer.

The sleeping-rooms are fairly large, and well ventilated, on the same floor. Twelve slept in each. During the day the wooden bedsteads are placed one above another. It was said that iron bedsteads are being generally introduced. Each young soldier is provided with a small cupboard above his bed. The non-commissioned officers had horsehair, the young men themselves straw paillasses. There was a stove in the room, but it was said not to be used.

The school-rooms are on the upper floor. The skeleton maps already referred to were here produced; one, of the two hemispheres, others illustrating Prussian history, showing the original size of the Prussian territory, its extent and condition under Frederick the Great, the whole course of its gradual extention, &c., very fairly drawn, and creditable to the young men.

The time devoted to the training which is given in the School Division appears long. What is now done in three years might as well be done in half that time. The object, however, is secured of retaining the service of the men during a lengthened period in the standing army.

III. REGIMENTAL SCHOOLS.

The Regimental Schools are chiefly intended to train up non-commissioned officers. This is more particularly the case in the artil-

lery, which does not obtain its *under* officers from the School Division at Potsdam.

IV. THE NOBLE-SCHOOL AT LIEGNITZ.

The Noble-School at Liegnitz is merely an endowed school, founded by the Emperor Joseph I. while Silesia was yet an Austrian dependency, and specially intended for young men of good birth in that country. There are some military foundations in the school for the sons of officers of good birth; and the two military men who take part in the instruction are paid by the state, on the same footing as officers employed in the State Military Schools.

[Of one of the Institutions above described (The Artillery and Engineers' School at Berlin) we shall give a fuller account, and in the meantime we close this comprehensive survey of military instruction in Prussia with the following reflections of the English Commissioners.]

VIII. GENERAL REMARKS ON THE SYSTEM OF MILITARY EDUCATION IN PRUSSIA.

1. Attention has often been drawn to the peculiar feature of Prussian Military Education, the double examination for the rank of officer. The principle adopted seems to be the exaction of a proof from *all* officers that they have received a good, general, and professional education, rather than the selection of a smaller number for higher training in a military school. The decree of 1808 first laid down the rule for the whole army, "that the only title to an officer's commission shall be, in a time of peace, education and professional knowledge,—in time of war, distinguished valor and ability."

2. The spirit of emulation is not so much called out in Prussia as it is in France. Early distinctions are acknowledged and appealed to, but somewhat sparingly. The following words express the view taken on this point:—

"A testimonial of fitness for the University," says Colonel von Holleben, (*i. e.*, to have passed the Abiturient examination) "dispenses with the examination for the ensigncy. In consequence of this rule fifty *Abiturients* on an average annually enter the army. These, as well as the *Selectaner* of the Cadet Corps, must be considered in point of scientific education, an excellent supply of officers."

3. It will be seen that in the above words there is no reference to those rewards and advantages which are the stimulus of competi-

tion. There appears some want in this respect both in the earlier and later training of officers. Thus, in the instance of the Cadet House, there are numerous *free places*, but these are assigned to young men, not from any proof of merit or exertion, but entirely because they are the sons of officers or state servants. The most distinguished pupils, the *Selectaner* gain nothing more than to be permitted to pass these two examinations before, instead of after, entering the army. Honorable mention, is, however, made of the candidates for commission who distinguish themselves in the Division Schools. But in the Staff School—the natural resource of energetic young officers—the competition (which the school asserts as its principle by its entrance examination) loses some of its force, by the order of the pupils on leaving the school not being distinctly marked. It should be mentioned as an explanation of these facts, that in the general civil education of Prussia, competition is little encouraged, less than in our own, and far less than in the French, or even in the Austrian education.

4. The military system of Prussia, and in some degree its military education also, appear to have various objects in view. Thus the Cadet Houses, where the free places are chiefly given to the sons of military men, seem intended to keep up a military *esprit de corps*, and it is impossible not to be struck by the strong class spirit prevailing in the Prussian army. At the same time means are taken, as above stated, to obtain a good supply of highly educated officers.

5. Prussian military education seems to have been constantly correcting and extending itself. Of this the Division Schools are a striking example; and they deserve attention, both because their plan is peculiar to Prussia, and for the improvements they have received. The Prussians at first established numerous Division Schools, but they afterwards greatly diminished their number; and the general inspector of military education now contemplates, both for the sake of the instructors and their pupils, a further reduction to three or four. A large military school in three or four towns in Prussia, intended to teach professional knowledge to young officers after some short practical experience in the army, is thought a better mode of giving such knowledge than to place isolated, or few teachers, in regiments or army divisions.

6. One chief means of improvement has been the bringing the whole education under a single head. At first there were distinct boards for the examinations in Prussia, and for the schools, with a view to maintain the independence of each. It was found, however,

that this led to a want of harmony between the schools and the examinations; and accordingly, whilst the board of examiners and the school professors are kept perfectly distinct, they are both subjected to the general inspector, who controls all the departments of military education. The effect of this has been to give more unity to all the teaching; an essential point where that teaching is entirely on the same subjects. By constant inspection of the schools, and the receipt of periodical reports from them, the general inspector of military education is able to compare the results of each, and to keep the whole system going at an even rate of progress.

7. Attention should be drawn to the somewhat complicated system for working the Military Schools in Prussia. There are two distinct boards, as we have noticed above, the supreme board of studies and the examinations board, one of which reports to the inspector-general on all examinations, whilst the other acts as his assessors and advisers with regard to the schools and on all other subjects of military education. Besides these bodies, each school has its own board of studies, which is generally formed by some one person belonging to the school, combined with distinguished officers or professors. Suggestions with regard to each school appear to originate chiefly from these latter bodies.

8. The department of military examinations and education is under the control of the general inspector, who "lays his proposals on matters of administration before the minister of war, but reports directly to the king in all matters relating to instruction and examinations."

THE ARTILLERY AND ENGINEERS' SCHOOL

AT BERLIN.*

OBJECT AND COURSE OF STUDY.

The object of the Artillery and Engineer School is to give to such young men of the Artillery and Engineers as have been found fitted for promotion, the education necessary for the proper performance of the duties of a Subaltern Officer, and to enable them to draw profit afterwards from their private studies and the practice of the service.

The complete course of study lasts two years and three quarters. The instruction is divided into three courses, bearing the name of *cœtus;* on joining the institution, the young men enter the first cœtus. Before the commencement of the studies, that is, about the 1st of October, the General Inspectors of the two corps direct the young men who are to enter the school to come up from their regiments and divisions. They receive their pay and clothing from their regiments until they are promoted to the rank of Officer.

The first nine months of each year of study are principally devoted to theoretical instruction, the three last exclusively to practice. In the third cœtus, the course finishes with the theoretical instruction on the 1st of July.

The instruction of the first cœtus is directed to prepare the students for the ordinary Officers' Examination, and at the same time to enable them to follow with advantage the further studies of the school. The instruction, during the first year, is common to all the students. Those who pass the Officers' Examination enter at the commencement of the second year into the second cœtus.

In the second cœtus the greater portion of the instruction, but not the whole, is common to the two arms. In the third cœtus an almost entire separation of studies takes place.

In all the studies which are common to the two arms, if the number of students is too great for a single class, parallel classes are established.

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* Translated from Helldorf's "*Dienst-Vorschriften der Königlich-Preussischen Armée.*"

THE STAFF AND AUTHORITIES.

A.—The Superior Authorities.

The *Curatorium* of the School is composed of the General Inspectors of the two corps. To it belongs the authority of issuing orders and regulations; no important change in these can be made without its sanction.

The General Inspector of Military Instruction receives yearly at fixed periods, reports upon the state and progress of the school.

The accounts are under the control of the War Department, with which the Director of the School is in immediate communication. Questions of principle and unforeseen cases of importance are decided by the *Curatorium*.

The Inspector of the School, who is an Engineer Officer when the Director is an Artillery Officer, and *vice versâ*, has the immediate oversight of it. It is his duty to see that the orders and regulations are strictly followed.

B.—The Executive Authorities.

The Director is appointed by the King. He is a Field Officer of either Artillery or Engineers, and has the rank of Commandant of a regiment. He has as assistant, a Captain appointed by the *Curatorium*. The Director is immediately responsible for the discipline and the finance of the establishment, and conducts its ordinary details, assisted by the Captain. He is also President of the Board of Studies; as such he exercises a general control over the instruction, and regulates the ordinary examinations.

Under the Director and the Board of Studies are four officers, three taken from the Artillery and one from the Engineers. They have the immediate charge of the students, and are themselves under the direct orders of the Captain.

The duties of Paymaster, Librarian, &c., are divided among them. They must also give at least two hours of instruction weekly to the pupils.

The Board of Studies consists of the Director of the Institution as President, and usually of the Senior Master of Mathematics, and the Instructors of Artillery and Engineering in the third cœtus. In equal numbers are likewise added Superior Officers of the Artillery and Engineers appointed by the *Curatorium*. The duty of the Board is to control the whole of the instruction, and to give an opinion when required, upon the performance and capacities of the teachers and students.

C.—The Teachers.

The teachers are to be selected as much as possible from among the Officers of Artillery and Engineers. Where this can not be effected, civilians of proved ability and experience are to be appointed.

The number of teachers is to be arranged with reference to the amount and extent of the studies, in such a manner that in the event of illness among them, no interruption in the instruction may arise. In addition to the teachers, there is a certain number of assistant-teachers, partly civilians, partly taken from among the fire-workers of the Artillery. The latter are employed under the Librarian, and in the practical instruction; they may also, in case of necessity, assist as clerks.

THE STUDENTS.

The maximum number of students who enter each year is 80; 60 from the Artillery, and 20 from the Engineers. In addition, a few young men may be received from the smaller German States. In the event of the number from one corps being short, an increased number may be admitted from the other.

The number in the second cœtus is variable. It consists, first, of the students previously in the first cœtus who have passed the Officers' Examination; and, secondly, of such young officers as are appointed to the Institution by the General Inspectors.

The students of the first cœtus lodge, as far as room will admit, in the school buildings; the remainder, as well as the ensigns of the second cœtus, not yet promoted to officers, are quartered in a neighboring building. At least two of the direction officers lodge in the school buildings; a third lodges in the other.

The Director may grant permission to a student, as a matter of favor, to lodge with his parents.

The students quartered in the school and the neighboring building dine together in the mess-room of the school.

The officers (students) of the second and third cœtus live in lodgings in the town, and mess where they choose.

ENTRY INTO THE SCHOOL, AND PASSAGE THROUGH IT.

The entry into the first cœtus of the institution is conditional on the applicant having passed, in the manner officially prescribed, the examination for ensign. The necessary certificates are forwarded to the Director of the School.

The instruction in the first cœtus embraces in general the subjects

required for the ordinary Officers' Examination, that is to say, the elements of Military Science, so far as every Subaltern Officer is obliged to know them. To this is to be added instruction in mathematics, in French, and in free sketching.

At the commencement of the instruction the teachers inspect the whole of the Ensign-Examination papers of the newly-arrived students, which are laid before them by the Director, in order the better to judge of their acquirements. During the first quarter they take pains to ascertain the ability as well as the amount of acquirements of each student, so as to be able to give a confident opinion upon him at the end of the quarter.

After the close of the first quarter a conference of the teachers, under the presidence of the Director, takes place, to form a report upon the students, and to furnish data for recommendations to the rank of ensign of such students as have given satisfaction by their conduct and progress. The students about whom the teachers have not yet been able to speak confidently, who, in certain studies, as in mathematics and the special branches of their arm, are behindhand, as well as those whose conduct has not been without blame, are proposed to the higher authorities for permission to continue to remain at the school. On the other hand, the Board of Studies proposes for dismissal from the institution, students whose conduct has been unsatisfactory, and principally who give too little hope of a favorable career. The Board is to express an opinion whether any prospect may be held out of a future recall to the institution, according as its unfavorable report has been founded on the want of ability or on the want of industry of the student.

The students favorably reported on are immediately, by the General Inspectors, appointed ensigns, subject to vacancies. The *Curatorium* decides regarding the further stay at the institution, or the dismissal of the others.

After the end of the second quarter, those pupils who can not yet be recommended for promotion to ensign are only in special cases allowed to remain till the end of the theoretical instruction of this year; if they can not then be recommended, they are sent back to their regiments.

Fourteen days before the close of the theoretical instruction for the year, that is to say, about the middle of June, the teachers give an opinion regarding each student of the first cœtus, as to whether or not they consider him capable of undergoing the Officers' Examination, and to pass into the second cœtus. These reports, joined to that of the Director, as regards the conduct of the students,

enable the Board of Studies to propose to the higher authorities either that permission may be granted to undergo the Officers' Examination, (and, if successful, to enter the second cœtus,) or that the student be sent back to his corps. Students who have been refused permission on grounds not altogether unpardonable, from presenting themselves for the Officers' Examination, or who in the course of instruction have been sent for any reason to their corps, with the prospect of being afterwards called back to the school, may, on the proposition of the Board of Studies, through the *Curatorium*, be granted a second and final entrance into the first cœtus.

The *Curatorium* decides in every case whether a student who has not qualified himself for entry into the second cœtus, may return to the first cœtus after having left the institution, or in case he shall have in the meantime passed the Officers' Examination, whether he may, as an exceptional case, enter the second cœtus. In a case of the latter kind, the applicant can not present himself for the Officers' Examination without having previously passed a preliminary examination at the school, to do which, the permission of the General Inspector of his corps is necessary.

The theoretical course closes at the end of June. During the month of July the students of the first cœtus are employed in surveying operations. It is during this month that the examination for the rank of officer before the General Examining Board takes place. The students who pass this examination enter afterwards into the second cœtus; those who fail are, at the expiration of the practical course of their year, sent back to their corps.

The students who pass the Officers' Examination, and are found qualified to enter the second cœtus, are then proposed for election to the officers of their corps. If the decision be favorable, their names are submitted by the General Inspectors to the King, to be appointed, on vacancies occurring, to the rank of Supernumerary (*Ausseretatsmässigen*) Second Lieutenant.

To assist the Officers of the Corps in making their election, an extract of the reports above alluded to is sent to them, so far as it concerns the students who have successfully passed their Officers' Examination.

It is an indispensable condition for entering the second cœtus, that, if a student of the first cœtus, he should have passed the Officers' Examination, or if he should now enter the school for the first time, that he should have the rank of Officer. The sum of acquirements necessary for the Officers' Examination forms the basis of the

instruction given in the second cœtus. In it the instruction ceases to be entirely common to the two arms.

At the end of the theoretical course of the second cœtus, a report of progress and conduct is drawn up, as in the first cœtus, by the Board of Studies, on the data furnished by the teachers as regards the studies, and by the Director as concerns the conduct of the students. In forwarding this report to the *Curatorium*, it is stated for each student whether or not he is considered qualified to pass the *former part* of the Special Corps Examination. Those who are unfavorably spoken of in this respect return to their corps, if there are no mitigating circumstances which permit a further stay in the second cœtus, following the decision of the *Curatorium*. They may either endeavor to obtain a transfer into another branch of the army, or by study and good conduct prepare themselves for admission into the third cœtus at a future period. But in this case they must not only be recommended by their corps, but they must also pass the *former part* of the Special Corps Examination.

The students recommended to present themselves for the *former part* of the Special Corps Examination undergo it before a Board appointed by the chiefs of the two corps in the beginning of July. It extends over the subjects of professional science which have been taught in the second cœtus. A particular regulation defines the mode of this examination, which is entirely written; it decides whether the student shall enter or not into the third cœtus.

The successful students pass, by direction of the *Curatorium*, into the third cœtus, while the unsuccessful ones, as well as those who have been reported unfit to undergo the examination, return to their corps. By good conduct and study they may obtain permission to come up again at the next examination for the *former part* of the Special Examination. Their definite return to the school depends upon their passing this examination, and upon the express order of the *Curatorium*.

The instruction in the third cœtus is chiefly directed to supply the special scientific knowledge required by each of the two arms. The students of the two corps, therefore, receive separate instruction. A further object of the instruction is to enable the students to make use of the knowledge which they have acquired, on which account instruction and practical application go hand in hand. Practice and theory go thus together in this the highest portion of the instruction, so that they both terminate at the same time, namely, at the end of the month of June.

Previous to leaving the School, the *latter part* of the Special Corps Examination is undergone before the same Board as for the *former part*. This examination tests their qualifications in their special arm, and proves their fitness for Artillery or Engineer Officers. The results of this part of the examination and of the former part of it passed at the close of the second cœtus, are combined by the Board, and forwarded to the *Curatorium*. Along with these reports is submitted a proposition for those who have passed the examinations to be admitted into their corps. In the preparation of patents (for commissions) they are antedated to the time of passing the Officers' Examinations, proper regard being had to the results of the Special Corps Examination for arranging the officers among each other.

Any officer who does not pass the Special Corps Examination, remains with the pay of an infantry officer in his corps until he either enters into another arm, or having obtained permission to re-enter the third cœtus, he qualifies himself for the final examination. A successful passing of the Special Corps Examination at this second trial can give, under the most favorable circumstances, no higher seniority than that of immediately after the officers who have passed their examination the previous year.

A.—*The Instruction in General.*

The general instruction may be divided into—

1. The theoretical part, designed with the view to the practical professional requirements of the students, and their further self-improvement.

The instruction ranges over—

(*a.*) Artillery.
(*b.*) Military Engineering.
(*c.*) Hydraulic Construction.
(*d.*) Elements of Tactics.
(*e.*) History of the Art of War.
(*f.*) Mathematics.
(*g.*) Theory of Surveying.
(*h.*) Physics.
(*i.*) Chemistry.
(*k.*) French Language.
(*l.*) Rules and Regulations of the Service.
(*m.*) The Horse.
(*n.*) Plan Drawing.
(*o.*) Free Sketching.
(*p.*) Descriptive Geometry.
(*q.*) Artillery Drawing.
(*r.*) Artillery Constructions Drawing.
(*s.*) Fortification Drawing.
(*t.*) Architectural Drawing.

2. The practical part of the instruction, designed by a series of practical exercises to exhibit the application of the theory taught, and to extend the knowledge previously acquired.

The practical part includes—

(*a.*) Visits to the Military Establishments and Institutions in Berlin and Spandau, examination of the objects, collections, models, &c., which they contain.
(*b.*) Chemical manipulation.
(*c.*) Examination of raw materials, of cannon, limbers, and ammunition wagons, of shot and shells, and of small-arms.
(*d.*) Management of machines.
(*e.*) Practical exemplification of the rules for placing guns with reference to the ground, and to tactical considerations.
(*f.*) Marking out and tracing batteries and field-works.
(*g.*) Drawings from Artillery objects, and from buildings, &c.
(*h.*) Being present at the practical operations of the Engineer Division of the Guards.
(*i.*) Solution of problems in the attack and defense of fortresses.
(*k.*) Practice in elementary tactics.
(*l.*) Practical surveying.
(*m.*) Artillery practice.

3. A course of Military and Gymnastic Exercises, requisite to prepare Officers for active military service.

They are divided into—

(*a.*) Exercises on foot.
(*b.*) Exercises with the different kinds of guns in position.
(*c.*) Fencing and gymnastics.

B.—*Instruction in Detail.—The Theoretical Part.*

The theoretical studies commence each year on the 1st of October, and end on the 30th of June. They may be reckoned, after deducting the vacation and holidays, to include a period of thirty-five weeks.

As a general rule, the studies take place only in the forenoon, namely, during the five hours between eight and one o'clock. Occasionally only are there hours of study for a small part of the students in the afternoon. A portion of the afternoons, during the theoretical course, are employed for drills and practice, but in no case more than twice a week, in order that the students may have the necessary time for recreation. The students are required (those who are officers excepted) to remain in their quarters in the evening, to prepare the work which has been allotted to them by the teachers.

The parallel classes of each cœtus, with the exception of the drawing classes, are, as a general rule, to be under the same teacher.

The theoretical instruction is distributed as follows:

AMOUNT OF STUDIES, WEEKLY.

Nature of Study.	1st Cœtus. Artillery and Engineers.	2d Cœtus.		3d Cœtus.	
		Artillery.	Engineers.	Artillery.	Engineers.
Artillery,	4	3		8	0
Military Engineering,	4	3		0	10
Hydraulic Construction,	0	0	0	0	2
Elements of Tactics,	4	0	0	0	0
History of the Art of War,	0	3		0	0
Mathematics,	6	6		In two divisions.	
				4	
Theory of Surveying,	2	0	0	0	0
Physics,	0	4		0	0
Chemistry, Lectures,	0	0	0	4	
Chemistry, Manipulations,	0	0	0	4	
French Language,	2	2		2	
Rules and Regulations of the Service,	2	0	0	0	0
The Horse,	0	0	0	2	0
Plan Drawing,	4	2	4	2	3
Free Sketching,	2	0	2	0	0
Descriptive Geometry,	0	1		0	0
Artillery Drawing,	0	2	0	2	0
Artillery Construction Drawing,	0	2	0	2	0
Fortification Drawing,	0	4		0	4
Architectural Drawing,	0	0	2	0	3
	30	32	34	31	36

REMARKS.

In the first cœtus.—All the instruction in this class is common to the two arms, and is equally divided among the six forenoons of the week.

In the first and second cœtus.—With reference to the mathematical instruction, it is particularly ordained, that each of the two mathematical teachers shall give instruction to the same students in the first and second cœtus, so that the one who teaches in the first cœtus one year, teaches in the second cœtus the year following.

In the second cœtus:—

1. The larger portion of the instruction, as the table shows, is common; in Plan Drawing the only difference is that the Engineers receive two hours' additional instruction.
2. The instruction in French, for a select number of the most advanced students only, takes place on two afternoons.
3. The instruction in Free Sketching for the Engineers takes place also on two afternoons.

In the third cœtus:—

1. About one-half only of the instruction in this class is common; in Plan Drawing the Engineers have one hour more instruction a week.
2. The Chemical Manipulations (in which a very small number only of the students share) take place on two afternoons.

3. The instruction in French, in which only those already selected in the second cœtus take part, also is given on two afternoons.

4. For mathematical instruction the class is formed into two divisions. The first consists of those pupils who, in the opinion of the teachers, are able to follow profitably the instruction in the higher mathematics. The remainder form the second division, and go over a second time what they have already learned, to which is added a variety of questions in applied mathematics, important to the Artillery and the Engineers.

TENOR OF THE STUDIES IN GENERAL.

First Cœtus.

Artillery.—Elementary Description of all the *matériel* of the Prussian Artillery, and of the basis of its arrangement. Effect of the different natures of guns, and the simplest rules for their employment.

General Military Engineering.—The elements of field and permanent fortification. The principles of the attack and defense of fortresses. General notions on the construction of military bridges.

Tactics.—General organization of an army. Formation of the different kinds of troops. Fundamental rules for the placing, moving, and fighting of the separate arms, as well as their combination. Occupation of ground. Attack and defense of positions. Field-service.

Mathematics.—Algebra and Arithmetic. Simple and higher equations. Progression series. The binomial theory for integral exponents. Series of powers and logarithms. Analytical trigonometry. Plane and analytical geometry. Plane trigonometry.

French Language.—Translation from French into German, with parsing.

Rules and Regulations.—Official correspondence, with examples. Discipline. Military code. Courts-martial. Courts of honor. Service in and out of garrison.

Plan Drawing.—Theory of representing ground. Principles of topography. Surveying. Drawing from copies and simple models. Knowledge and description of the different conventional marks.

Free Sketching.—Drawing of straight lines, broken lines, and angles. First principles of figure drawing. Hatching with black chalk. More difficult studies in figure drawing.

Second Cœtus.

Artillery.—Description of the organization of the Prussian Artillery. Rules for the employment of artillery in the field and in sieges.

Special Military Engineering.—Extension of the course of field and permanent fortification, given in the first cœtus. Extension of the instruction on sieges. Formation of camps. Specialities of military engineering, in so far as it is of interest to artillerists.

History of the Art of War.—History in early times, in a very general manner; that in the middle ages, as they approach modern times, in greater detail; in modern times, very fully. Organization of the armies and mode of conducting war at each remarkable period, illustrated by the description of some campaigns and great battles.

Mathematics.—Solid geometry. Spherical trigonometry. The theory of projections. Theory of co-ordinates and conic sections. Statics, geostatics, and hydrostatics.

Physics.—General properties of bodies. Laws of the equilibrium of solid, fluid, and aëriform bodies. Heat. Application of steam and gases. Measurement of heights. Hygrometry. Acoustics. Optics. Magnetism. Electricity. Electro-magnetism. Magneto-electricity.

French Language.—Exercises in translating German into French, for a select number of pupils, about one-third of the whole.

Artillery Drawing.—Use of drawing instruments and scales. Drawing of the *matériel* of the artillery, and principally of the separate parts of an object in different views and sections, to a certain scale, without the original.

Artillery Constructions Drawing.—Construction of the different limbers, gun-carriages, &c., and the principles of their arrangement, forms, proportions, and admeasurements; in greater part, however, intended only as illustrations of the rules of perspective.

Fortification Drawing.—Instruction in the composition of drawings; the practice includes representations of projects of fortresses and their details in plan and section, and in cavalier's perspective (bird's-eye view); both etched and shaded with Indian ink, and colored. The chief object is to qualify the pupils to understand, and to prepare correctly, drawings and plans of objects in field and permanent fortification.

Plan Drawing.—Further practice in drawing of ground, with objects, buildings, &c., marked in black and colors. Further progress in geodesy. Sketches and reconnaissances.

Architectural Drawing.—Perspective. Drawings of architectural decoration in outline, with the lines of shadow, but without further detail.

Free Sketching.—Further figure-drawing. Landscapes and the drawing of ornaments, for the more skillful students.

Descriptive Geometry.—The theory of descriptive geometry. Projections of various bodies in space, upon planes. Drawing according to proportional scales. Theory of light and shade of drawings.

Third Cœtus.

Artillery.—History and Literature of artillery. Review of the general relations of the artillery system in the principal states of Europe. Scientific basis of artillery objects, and their technical description. Theory of the parabola and of projectiles. Organization and employment of artillery, considered in its highest point of view.

Exclusive Military Engineering.—Special application of the rules for sieges under given circumstances more or less connected. Complete instruction in building, and its application shown by projects for given sites.

Hydraulic Constructions.—General principles of the science. Knowledge of the construction of such works, of which the principles should be known to engineer officers. In this is chiefly to be considered fascine work for the protection of the banks of rivers and canals, the construction of bridges and sluices, and the laying the foundation of heavy masonry in water.

Mathematics.—(For the first division, about a quarter of the class.)—Differential and integral calculus. The higher geometry. Analytical mechanics and hydraulics.

(For the second division, about three-quarters of the class.)—Repetition of the most important part of the studies already gone through in the first and second cœtus, with practical useful problems. Mechanics and hydraulics, as well as some instruction necessary for artillerists, but so as not to require the higher analysis, and more of a practical than of a theoretical nature.

Chemistry (Instruction.)—The necessary preliminary knowledge of theoretical principles. Treatise of separate substances (of the metalloids and their indifferent combinations, of the acids, of the metals,) all illustrated by experi-

ments. To conclude with a survey of the composition and alteration of the surface of the globe from a chemical point of view.

(Manipulation.)—Instruction in the principles of qualitative chemical analysis, illustrated by experiments. Manipulation by the students under the superintendence of the instructor. Instruction in the principles of quantitative analysis. Analysis by the students, of substances employed by the artillery. (Only four or five of the best qualified take part in these experiments.)

French Language.—Select conversation (only for the already selected students in the second cœtus.)

The Horse.—Natural history and anatomy of the horse. Good and bad points. Food. Internal and external sickness, with the mode of discovery and cure of of the same, as far as practicable, by the means to be had on actual service. Shoeing.

Artillery Drawing.—Continuation of the instruction. *Matériel* of the artillery, represented as combined artillery objects, partly on a given scale, partly drawn from a real object, by the more skillful students.

Artillery Construction Drawing.—Construction of each description of cannon. Principles of their forms, proportions, and sizes. Problems on the construction of existing and not existing guns, carriages, &c. Construction of the artillery *matériel* of foreign powers.

Fortification Drawing.—Projects of field fortification, to be constructed of earth, or of earth and gabions, with application to the nature of the ground. Drawings with the use of Von Prittwitz' copies of the fortification of places, as a continuation of the fortification drawings begun in the second cœtus. For all these exercises in projects and drawings, the concert of the teacher of exclusive engineering is required.

Plan Drawing.—Practice in copying and reducing large plans. Drawing of plans of battles with the position of the troops, and of plans of sieges, with the trenches and batteries.

Architectural Drawing.—Architecture in its application to military buildings, done in India ink. Finally, practical exercises in copying buildings.

PRACTICAL EXERCISES.

These are carried on, as has been already remarked, in part during the nine months of theoretical instruction, on some of the afternoons, but they principally take place during the three summer months of July, August, and September, in the forenoon. They commence early in the morning, and often last till the afternoon, on which account there are no evening hours of study during this period. As the students of the third cœtus return to their corps at the beginning of July, those of the first and second cœtus only take part in this practice. The visits to the Fortress and Military Establishments of Spandau, and the preparation of projects of military constructions, and of reconnaissances, must be made during the period of theoretical instruction. It is therefore suspended for one day for the students of the first cœtus, and for three days for the Artillery, and five days for the Engineer students of the third cœtus.

The distribution of time for each cœtus is as follows:

DURING THE NINE MONTHS OF THEORETICAL INSTRUCTION.

	Number of Days employed.				
	1st Cœtus. Artillery and Engineers.	2d Cœtus.		3d Cœtus.	
		Artillery.	Engineers.	Artillery.	Engineers.
Visits to the Artillery Workshops,.....	2	0	0	4	0
To the Collection of Arms in the Arsenal.....	1	0	0	0	0
To the Models of Fortresses in do....	1	0	0	0	0
To the Ordnance, Gun-carriages, Ammunition-wagons, &c., in do.....	4	0	0	0	0
To the Foundry and Boring Machinery	2	0	0	2	0
To the Iron-foundry, and to one of the large Manufactories of Machinery in Berlin,.....	0	0	0	2	0
To the Fortress of Spandau, the Powder-mill, and Small-arm Factory,..	1	0	0	0	0
Working in the Laboratory,.....	12	12	12	0	0
Examination of Ordnance,.....	0	0	0	6	0
" of Gun-carriages, and Ammunition-wagons,.....	0	0	0	6	0
Examination of Shot and Shell,.....	0	0	0	2	0
" of Small-arms,.....	2	0	0	0	0
Practical representation of the Rules for placing Guns:					
With reference to the ground,....	0	2	2	0	0
On given tactical conditions,....	0	0	0	4	0
Solution of problems in the art of Sieges, with reference to an actual fortress and the country surrounding it (Spandau,)	0	0	0	3	5
Practice in Elementary Tactics,.....	4	0	0	0	0
Drawings of Ordnance, Carriages, &c...	0	12	0	0	0
" of Buildings, &c.....	0	0	0	0	14
Practice in Geodesy,.....	12	0	0	0	0

DURING THE REMAINING THREE MONTHS.

Practice in Geodesy,.....	16	28	28	Nil.
Practice in Fortification of the 1st cœtus, with the Engineers of the Guard.....	12	0	0	"
Practice in Fortification of the 2d cœtus,	0	10	10	"
Visits to the Models of Fortresses in the Model-house, ...	0	2	2	"
Gun Practice, proof of gunpowder, the management of machines, &c.....	14	14	14	"

Remarks.—The employment of time in the last three months above given, requires the whole of the months of July and August, and about the first third of the month of September, after deducting fourteen days for the Officers' Examination for the first cœtus, and occasional days lost through bad weather. The remaining two-thirds of September are given for vacation, as well to afford recreation to the teachers and students as to allow of the repairing and cleansing of the school-buildings.

MILITARY AND GYMNASTIC EXERCISES.

The month of October is appointed by the Director to the fitting and making uniform the regimental clothing brought with the stu-

dents from their corps. Military exercises then take place once a week for two hours in the afternoon, till the 1st of April, or for about five months.

The military exercises are carried on under officers of the garrison, namely, a Captain and two Lieutenants of the Artillery of the Guard. They put themselves in communication with the Director to arrange the time, nature, and extent of the exercises.

The exercises consist of—

1. *Exercises on Foot.*—The whole of the first cœtus here take part, but only so many of the second cœtus as are required as non-commissioned officers. Considering the composition of the squad, (Artillery and Engineers,) and the object of the exercise, the perfection of the students in company-drill is less to be attempted than the endeavor to give to each a good position and carriage in the front as well as in the ranks, and more particularly to accustom them to military order and precision.

2. *Exercises with different descriptions of Guns in Position.*—In preference, the light field-pieces of the year 1842 are to be used for drill, and correct, united and prompt execution required. With the siege-guns, every student is instructed and practiced with at least one calibre of each nature.

In addition to their military exercises, there are also—

3. *Fencing and Gymnastics.*—In these exercises the students of the first cœtus only take part, and for two hours of the afternoon each week, during the first six months. There is neither time nor appliances to admit of the students arriving at a high state of excellence. The practice in fencing is only intended to give confidence in the use of arms, that in gymnastics to produce activity, and to afford bodily exercise to young men much occupied in study.

EXAMINATIONS AND CENSURES.

In addition to the several examinations already enumerated, by which the fitness of the students for a certain rank or for promotion into a higher cœtus is shown, some other examinations take place.

1. For the purpose of enabling the Director and the Board of Studies to learn the progress of each separate student, and to confirm by their own knowledge the opinion given by the teachers, there is twice in each quarter an oral repetition of some portion of such instruction in the first and second cœtus. The period of the examination is previously named by the Director.

2. To give a general view of the progress of the entire year, and

to incite the students to study, a public oral examination of those in the first cœtus takes place at the close of the theoretical instruction, in presence of the higher authorities of the school, superior officers of the two arms, and other persons interested.

As a further incitement to the students, and as a warning to those whose diligence or conduct has not been satisfactory, the quarterly "censures" are read out to the assembled cœtus. In general the names of the students are not mentioned, a number known to the individual only being used instead. The best pupils are, however, openly commended by name.

In the first cœtus, on the other hand, those pupils who have obtained very bad "censure" are mentioned by name.

FINANCIAL RELATIONS.

The annual expense of the School is fixed at 16,049 dollars. The sum is distributed as follows:—

Personal.

Salaries and allowances of Teachers	10,731	
Pay and allowances of the Staff	3,478	
		14,209
Practical exercises	520	
School necessaries	720	
Keeping up materials for instruction	110	
Cleansing the rooms	130	
Lighting	100	
Bureau expenses	210	
Covering unforeseen expenses	50	
		1,800

In the event of war, and if the instruction is suspended for an indeterminate period, the salaries of the civil teachers cease. Application is not to be made to the King for the grant of a provisional indemnity, except under very peculiar circumstances.

The payment of the salaries and allowances is made monthly and in advance.

The administration of the funds is directly under the supervision of the Director. The Treasurer carries out the details. The superior orders for the administration of royal grants are most strictly to be followed.

The annual accounts are forwarded by the Director to the War Department.

The property of the School consists of—

The Library, the Collection of Instruments and Models for Artillery and Engineers, the Collection of Physical Instruments, the Collection of Chemical Apparatus, and the School Utensils.

The principal object of the Library is to serve as materials of instruction for the teachers and students, and the Officers of Artillery and Engineers present at the Institution. After that, as a center, for the collection of all the best works, old and new, on Artillery and Military Engineering.

The Director and Board of Studies take care that the instruments and apparatus for the studies are always kept complete and in good order. As the means of the school do not thoroughly admit of the collections keeping pace with the progress of science, special care is taken that at least the most necessary articles are not absent.

The utensils of the school are kept always complete, under the supervision of the Director.

The property of the school is examined yearly by the Director and Board of Studies, and a report to that effect sent in with the annual accounts.

PROGRAMMES OF THE PRINCIPLE SUBJECTS TAUGHT

IN THE

ARTILLERY AND ENGINEER SCHOOL AT BERLIN.

I. ARTILLERY.

THE instruction must commence with the first elements of the science, since the new arriving students have little preparatory knowledge. It must be carried on to such an extent that the pupil may be able, after going through the first cœtus, to pass his *officer's examination*, and after the completion of the entire course, not only to show at his *special* examination that he possesses the positive knowledge required for the ordinary duties of the service, but also to prove that he is qualified for continuing his studies by himself.

The Engineer pupils who close their instruction in artillery at the end of the second cœtus, are to be instructed in the composition of artillery, in the effect and the use of cannon, but more especially in its employment in sieges.

From this general notice of the limits of the course it is evident that neither a perfect exposition of the theory nor complete practical exercises are expected. Still to train the students properly in the different directions which an artillery education requires, the instruction must not consist only in a theoretical lecture, but be aided by judicious directions for drawing, and be perfected by practical exercises. For the attainment of the two latter objects special prescriptions are given, to which we refer.

Instruction in artillery is closely connected with the lectures on mathematics, physics, chemistry, tactics, fortification, and veterinary science.

a. As special points may be mentioned, *in mathematics*, calculation of contents, and fixing the centers of gravity, of cannon and its parts; calculation of piles of shot; strength, direction, and distribution of recoil on the separate portions of a piece of ordnance; theory of machines, of carriages, of parabolic and projectile curves, and calculation of the flight of rockets. In all these cases the mathematical lecturer develops the necessary formulas for the artillery student, but their application belongs to the course of artillery.

b. In physics.—Explanation, notice, and determination of the specific gravities of the materials used in artillery. The law of gravity. The absolute and relative strength of woods and metals. Friction. Resistance of the air. Expansive power of gases, especially of those generated by gunpowder.

c. In chemistry.—The general laws of chemical action of bodies on one another. The simple elements of the materials used in artillery. The chemical properties of their combinations. The acids exhibited in the combustion of gunpowder and their action on metals; the processes used in the reduction and manufacture of metals up to the point where they are fit for use in artillery; chemical analysis of gunpowder and of the most common metal-alloys. The action of the atmosphere on substances exposed to it, which are used in artillery.

d. In tactics.—The organization and tactics of artillery, so far as they stand in direct relation to other arms. A complete account of the conduct of artillery when coöperating with other troops.

e. In fortification.—Everything referring to the tracing, the relief, and the

construction of fortifications; attack and defense of field-works by infantry and cavalry; complete exposition of the art of besieging, with a discussion of all the duties of an engineer, a sapper or miner, both in the attack and the defense of a fortress, also the use of infantry and cavalry in sieges, with the omission of the points specially belonging to artillery.

f. In the veterinary art.—The anatomy and physiology of the horse; general rules for feeding, treatment of diseases, and disinfection of the stables and utensils.

The instruction in the first cœtus must, as already mentioned, be so calculated, that the students at the end of the course of lessons may be able to satisfy perfectly the requirements of the *Officer's examination.*

As a further prosecution of the same subjects of instruction in the second, and again in the third cœtus, would lead to a great loss of time and to tiresome repetitions, the lectures are to be so planned that the separate subjects to be treated in the first and second cœtus, taken together, are of sufficient extent for the Engineer pupils in general; the further developments necessary for the Artillery pupils are reserved in preference for the third cœtus.

A. IN THE FIRST CŒTUS.

The separate subjects of the lecture are—

1. Definition and distribution of arms.

2. Theory of gunpowder: component parts—manufacture—ignition—force. Proving. Storing. Transporting. Necessary precautions in manufacturing. Marks of damaged powder, and the possibility of restoration. Mention of the substances which may be used in place of gunpowder for various military purposes.

3. Cannon. Materials. Dispositions. Manufacture. Proving. Storing, and duration.

4. Gun-carriages. Limbers and other artillery carriages. General explanations on the construction of carriages, with particular reference to those used for artillery. Materials. Distribution and composition of gun-carriages. Limbers and wagons. Their examination and storing.

5. Military combustibles. Elementary notions. General account of laboratory work and regulations; also with reference to later proceedings in a laboratory, and, omitting all figures not absolutely necessary, a description of the preparation of fire-works, matches, ammunition both for artillery and for small-arms, signal lights, and particular kinds of combustibles. Their packing and storing.

6. The service, working, and moving of cannon, and of artillery carriages, with account and description of the machines in use by the Prussian artillery; but without special explanation of the official regulations.

7. Firing. Theory of the movement of projectiles, of the effect caused by their movement, and the mode of turning this action to the best account for military purposes. Elements of the theory of firing. Practice. Various descriptions of fire; their effect, and their employment for various sorts of guns.

8. Small and side-arms. Purpose and description of the composition and arrangement of small-arms. Their manufacture, storing, and the practical rules for their use. Purpose and description of side-arms. Fabrication, proving, effect, and use of them.

B. IN THE SECOND COETUS.

The instruction in the second coetus is a continuation of the lectures of the first coetus, and embraces the use of artillery in the field and in sieges. Its object is to bring the Artillery students to that point that they are able, at its close, to discharge satisfactorily the ordinary practical duties of the service, and be prepared to follow the course of the third coetus, and to give to the Engineer students, who, in the third coetus no longer receive instruction in artillery, all the knowledge of the subject required for their future profession. The instruction must therefore be complete enough for the Engineers, and give the Artillerist a solid and thorough preparation for the third coetus.

Instruction in the second coetus should comprise, in particular—

1. The organization of the artillery: purpose and considerations in the putting together of all parts of artillery material, both in tactical and administrative respects, with historical mention of the diversities of practice of other Powers.

2. The use of artillery in the field. Marching and tactical movements. Taking up position. The engagement itself, and conduct in some particular cases; for example, in defile fighting, in entrenchments, passage of rivers, &c.

3. Use of artillery in sieges:—

a. *For Attack.*

Planning and throwing up the batteries. Preparation and use of the different kinds of materials of construction. Different sorts of batteries. Methods of construction. Repairing of damaged batteries, and the calculation generally of all the materials necessary for constructing them.

Purpose and equipment of besieging batteries, with the preparations, special and general, for a regular attack.

Proceedings in the regular attack, and their modifications in irregular sorts of attack, occasioned by the situation of the fortress with reference to the surrounding ground, or by the special nature of the defenses.

Proceedings after capture, and when the siege is raised.

b. *For Defense.*

The equipment of the fortress. Determination of its artillery. Preparations in the fortress when it is declared in a state of siege. Conduct of the artillery in the regular attack, and against irregular modes of attack, as well as in particular cases, such as when in detached isolated works, when the place is relieved, or when the garrison fight its way out.

C. IN THE THIRD COETUS.

In the artillery course of the first and second coetus, the students have gained a general knowledge of the materials of artillery, as well as its organization and use as an Arm; but the lectures were for the most part limited to what was of the greatest immediate consequence, viz., the description of the actual condition and relations of the Prussian artillery.

The object of the instruction given in the third coetus is, on the one hand, to expose the scientific laws of artillery and its various parts, and, on the other, to track the historical development of the Arm, so as by this means, and by consideration of the constitution of foreign artilleries, to extend the views of the

students beyond our own practice, thus to form their judgment, and induce them to think and contrive for themselves.

In the comparison of our own and foreign existing systems with the results of scientific considerations, the teacher should proceed with caution, and not raise in the young men the inclination to or the habit of crude and officious criticism. Investigation of things as they exist must, therefore, not confine itself to the mere search after defects; it can be only profitable when employed to test our own powers at improvements, and to discern thereby the difficulties and impediments that accompany them The value which speculative reasoning has for the purposes of the artillery ought to be properly esteemed by the students, but, in face of the results of experience, not be estimated too highly; and in the comparison of different artilleries one with another, the influence must not be overlooked which the peculiarities and the history of a country ever exert on its institutions.

The final aim of the artillery instruction in the third cœtus must be a higher degree of preparation for the future practical ability of the students. As regards the material portion of the artillery, the students are to acquire a general knowledge of the construction, fabrication, and proving of the *matériel*, and for the tactical part, it is above all things to be made an object that they be made capable, by the instruction given them, of greater dexterity and confidence in dealing with special cases in the field or in siege operations.

The instruction commences with:—

1. Organization of the artillery service. The general relations of the artillery service are to be explained according to its different purposes, as an arm both in technical and administrative respects, then the principles for the organization of the service and of its separate portions in peace and war are to be developed, and comparison made with those carried out in the principal foreign artilleries.

At the same time, on the one hand, more details are to be gone into on the different branches of the artillery service (field, siege, fortress, and coast artillery, the technical and the administrative branches,) than was done in the second cœtus; and on the other, those considerations must be kept sight of in which the artillery appears as a portion of a greater whole, as in its relation to the Army and to the State.

2. Artillery, regarded as an arm. Since the elementary rules for the use of artillery in war have been given already in the second cœtus it will be the object in the third cœtus, first, to develop the principles of artillery tactics in the field, and in sieges, from an extended point of view, and then to apply the rules for the movements, placing in position and fighting of the artillery to the bodies now actually used in war, and to examine the great questions that may hence arise. For the field artillery, the tactics of single batteries and of masses of artillery and the collective relations of the artillery of a *corps d'armée* and of an army, must be shown. For sieges there will be less occasion to treat of the separate means of defense by artillery than of the various combinations under different circumstances, of its diversified applications.

To give this instruction its most practical tendency, historical examples of battles are to be taken, and not merely their results adduced, but the circumstances gone through in detail. These are to be compared with the rules previously given, and the causes and effects of any discrepancies, as far as practicable, and with caution, explained.

Themes are then given out of campaigns and sieges, in working which the students are to show applications of tactical rules under given circumstances.

As regards the preparation for the field and the conduct in marches, quarters, camps, or bivouacs, what was necessary has already been taught in the second cœtus, as far as concerns a corps of artillery as large as a battery. In the third cœtus, therefore, only more extensive and important relations have to be explained.

Finally, as the students at the close of the third cœtus are to enter immediately into active service in the regiments, it will be useful to give them a general view of artillery duties in time of peace, of which no mention was made in the first and second cœtus, and to show the principles on which they rest. Further, the education of the men, the selection, management, and care of the artillery horses, instruction in riding and driving, the various exercises in serving and moving the guns, artillery practice, the different fatigue duties, conduct in manœuvres, detachments, &c., are to be particularly explained.

3. Artillery in a technical and administrative point of view. In the instruction given in the first and second cœtus, a descriptive notice only was given, as regards artillery material, of the arrangement and effect of what actually exists; and the reasons for this arrangement were added only so far as was necessary for this principal object.

In the third cœtus the pupils are to learn by the inductive process how, according to existing principles of natural science and of tactics, with the known mathematical and technical aids, artillery material must be contructed, manufactured, and proved, so as to obtain the desired end in the highest degree; and then our existing material and that of other countries are to be compared in the manner above stated with the results thus obtained.

To this end, in the lectures, first, the necessary explanations of artillery requirements are to be brought forward from the doctrine of mechanics; after that the fabrication, proving, and action of gunpowder are to be introduced; and finally, the construction, fabrication, and examination of cannon, carriages, and ammunition of the artillery and of small-arms.

Of course the details of powder-mills, of cannon foundries, of artillery workshops, of laboratories and small-arms manufactories, are here to be explained.

The action of projectiles and the mode of applying it, are to be scientifically explained, by the aid of the parabolic and projectile theory, as well as the principles upon which artillery experiments are to be conducted.

Finally, the principles of the management of the artillery material in the artillery dépôts are to be explained.

4. The course of instruction will be closed by an historical description of the progress of artillery, and by an historical review of its literature.

D. GENERAL DISTRIBUTION OF THE TIME.

The total number of hours is, according to the constitution of the school—

For the first cœtus,	35	weeks of	4	hours	= 140	hours.
" second "	35	"	3	"	= 105	"
" third "	35	"	8	"	= 280	"

The exact number of hours dedicated to each division must be stated by the teacher in the first instance in his special plan for lessons, as they in part depend

upon his general experience. But, at all events, all the above-stated subjects for the first cœtus must be taught in the prescribed periods.

The lecture in the first cœtus must by no means be a mere mechanical preparation for the *Officer's examination;* even here the understanding of the pupil is not to remain unoccupied, though the memory is to be had recourse to in a very high degree, and the historical form, that is, description of objects as they are, predominates.

The principles of the arrangements can only be taken up in their chief features, (partly because) time will not allow a farther advance, and partly because the progress of the students in the other studies is not yet sufficiently forward.

In the second cœtus the advantage has been obtained that the students have gained a knowledge of the entire material of artillery in its various relations, and the lecture gives, therefore, an introduction to the use of artillery in the field and in sieges; and with special regard to a fundamental knowledge of the details, and with the view to what is necessary to complete the Engineer pupil and make an efficient preparation of the Artillerist for the third cœtus, aims at a somewhat more scientific treatment, without going into the full comprehensive details reserved for the latter student. For the same reason, this portion of the lectures is confined nearly throughout to the explanation of existing conditions of our artillery, and only where the necessities of the Engineer student may demand it, can mention be made of the earlier material, or of the most important matters of foreign artilleries.

The instruction, therefore, of the first and second cœtus is directed more to the general and historical, that of the third cœtus, more to the special and scientific culture of the student; the materials were there collected which are here to be worked up.

From this general point of view proceed also the methods which are to be observed by the teachers in each cœtus.

The principal point to be kept hold of in all three cœtus is, that everything that can be shown the students, or which they can learn by their own manipulation, should be brought visibly before them, and as far as time and circumstances permit, should be actually put in practice. The material objects, in their actual state for use, must as often as possible be shown and explained, for which the Practical Exercises offer the best opportunity to which reference is here therefore made.

After these, a collection of models, diagrams, tables, and literary notices are necessary, which may be partly used for immediate instruction in the class, and partly furnished the pupils as a necessary and time-saving aid to the memory.

Deficiencies in these aids to the lectures are to be laid before the Direction and Board of Studies by the teacher, and supplied as far as the existing means allow.

Those cases in which the proceedings are fixed by certain regulations require special mention; for instance, the transport of powder, examination of cannon, drills, harnessing of horses, stable and camp service, &c.

All these regulations are grounded on certain principles, from which no deviation can take place without evil. The method of drawing them up is, however, variable, on which times and circumstances, and even the views of the superior authorities, have influence.

It is, therefore, highly necessary that in this respect the essential be carefully in the instruction separated from the accidental, and by omitting the latter, not only gain time, but hinder that the students accustom themselves in a slovenly manner to look only to forms, and to seek in them the true being and life of artillery.

A true exposition of the principles on which these regulations rest ought not to be omitted from the lectures. They will suffice to prepare the students to act correctly in every case that occurs, for which actual service gives them, moreover, the separate instruction. The more completely the teacher keeps this point in view the less need he fear to form his pupils to immature critics, since the well-informed officer will more easily enter into the spirit of each such regulation, and more exactly carry it into execution for the benefit of the service, than he who has been accustomed to keep without reflection only to the dead letter; this, in the varied phases of practical life, will often enough leave him without guidance, unless he knows how to find it within himself.

As amongst the many existing class and hand-books for the artillery, none is entirely adapted to form a basis for the lectures, the formation of a special plan of lectures for each cœtus is indispensable, that the lecturer may have a defined path, and the students an assistance in their repetitions.

II. GENERAL AND SPECIAL ENGINEERING IN THE FIRST AND SECOND CŒTUS

The lecture commences with the first principles of fortification, supposes no previous knowledge, and comprises—

(*a.*) Field fortification, attack and defense of a redoubt, communication in the field, and,

(*b.*) Permanent fortification, the art of besieging, with the example of a siege that has actually taken place.

In the first cœtus it must be so far carried out that the pupil is capable of passing his *Officer's examination* according to the regulation of the 26th March, 1846. In the second cœtus the general knowledge of field and permanent fortification acquired in the first is carried on in such a degree as both Artillery and Engineer officers require to form a good foundation for the particular professional study of both arms in the third cœtus.

In the formation of the special plan of the lecture the instruction-regulations for artillery and exclusive engineering in the third cœtus are to be kept in view, so as to prepare for these subjects by the nature and the method of the instruction.

The principal contents of the lecture are—

A. IN THE FIRST CŒTUS.

a. *In Field Fortification.*

A correct description of the profile, the ground plan, the technical obstacles and modes of strengthening, the construction, and elementarily also, the use of field-works; attack and defense of a redoubt, and the military communications in the field, as roads, fords, and bridges.

b. *In Permanent Fortification.*

Exposition of the essential principles for plan and profile; acquaintance with the parts of a bastioned fortress with the outworks; special acquaintance with

a work on Vauban's first system, and its improvements by Cormontaigne. Knowledge of the characteristics of the Italian, Dutch, and French fortification, of the ideas of Rimpler and Montalembert, as well as of the latest fortifications in Prussia; lastly, a knowledge of sieges as regards a regular attack and defense. The art of construction is taught to the Engineers in the third cœtus.

B. IN THE SECOND CŒTUS.

Applied art of fortification, and, namely, attack and defense of the various sorts of field-works, castrametation, permanent fortification, provisional fortification, and sieges. At their proper places, are to be introduced the precepts of military constructions which are suitable alike to the Artillerist and the Engineer, as well as the conduct of infantry and cavalry, and the duty of the Engineers in sieges.

Distribution of Time.

The first cœtus receives four, the second three hours weekly; therefore, in thirty-five weeks, the first 140, the second 105 hours. The number of hours which are to be dedicated to each portion will be indicated by the teacher in his special plan of the lectures, as it in part depends upon his experiences. All the above-named subjects must, however, be gone through within the prescribed period.

Before every principal division of the lectures, a general statement of its purport and essential principles is given; then follows a short historical exposition which is to explain the connection, the employment, and the thence arising conditions of the subject under consideration in reference to the other parts of the art of war.

The precepts hence deducible on the form of the parts of a fortification, and on the subsisting relations of fighting, are to form the latest and principal portion of each lecture.

The lecture is to be given in detail in such a manner, that its precepts may be deduced from one another in a way suited to the powers of perception of the pupils, and their mental powers accustomed to the carrying out of principles, rather than to a blind adherence to absolute regulations. To avoid repetition, the details of those doctrines which belong to different places are to be given only once, namely, where they are first required; and afterwards reference only made to them.

The military element, as indispensable both for the Artillerist and Engineer alike, is to be kept continually in view.

As regards the principal divisions, oral repetitions may be made from time to time for greater clearness; and, since individual and continued attention and self-reflection alone render a well-grounded progress in the student possible, written themes, besides those prescribed, are particularly recommended. It will not be necessary to submit each individual essay to a separate correction, but the teacher may content himself each time with giving a general view of important defects in the treatment of the subject, and then reading aloud one or more of the essays that have best succeeded, and showing by their analysis how the subject could be best treated.

In both cœtus, the existing models and full sized drawings in the school, as also the models in the arsenal, and for the second cœtus more especially the models of fortresses in the model-house, are to be used.

The means employed to complete the instruction in both cœtus, are fortification drawing, practical exercise in field-works, and an inspection of the fortress of Spandau.

The lectures are given without any fixed hand-book, from manuscript drafts or notes.

III. EXCLUSIVE ENGINEERING IN THE THIRD CŒTUS.

The instruction in General Engineering in the first cœtus was intended to teach the Artillerist and Engineer so much of the art of fortification, of sieges, and of field-works as is requisite for officers of every arm, and is necessary for the students to pass their *Officer's examination*.

In the second cœtus this instruction was enlarged, and connected with its application to field and permanent fortification, to such extent as the kindred arms of the artillery and engineer corps required equally to know, that they may execute effectually their separate duties in fortification and sieges.

The instruction in Exclusive Engineering in the third cœtus is, however, intended solely for Engineers, as it teaches only professional matters which the engineer shares with no other arm of the service; while, on the other hand, the Artillerist receives a special instruction in those branches which are only necessary for the artillery officer.

Since the lectures would receive a too great and heterogeneous extension, if to them were to be added that portion of hydraulics which the engineer officer ought to know, without being immediately connected with his military constructions, and if further, civil architecture applied to military buildings was touched on, these subjects will be taught contemporaneously in the third cœtus by special instructors, and are therefore in the lectures on Exclusive Engineering not to pass the limits of that instruction. Their respective teachers must receive reciprocally special information of each other's plan of lectures, and give mutual help by communications and inquiries where the studies might come into collision.

The teacher of the Exclusive Engineer class must learn the extent of those subjects of instruction which have been already treated in the lectures on Special Engineering in the second cœtus, and not only by inspection of the programme, but by personal consultation with their respective teachers.

In more remote relation, the instruction connects itself with the earlier lectures on artillery, tactics, history of the art of war, mathematics, physics, chemistry, and the exercises in plan-drawing and surveying. The special programmes of instruction of these branches of study are also to be taken notice of by the teacher, that nothing may be twice taught, and that where the use of doctrines from those studies is necessary, he may merely refer to them historically.

This instruction comprises, after an introduction, the following principal divisions.

1. The application of the rules for sieges already given to particular cases, with a general regard to the ground, more especially of irregular fortresses, shown by various remarkable sieges.

2. A theory of construction as auxiliary science in the execution of engineering works for field or permanent fortification, and in the execution of military constructions: building materials, modes of building, and the application of both for given purposes.

To this part belong—

a. A knowledge of the different building materials from the animal, vegetable, and mineral kingdoms; their production and preparation for various building purposes, and the data, so important in practice, regarding their durability and mode of employment.

b. The theory of the use and combination of these building materials for constructive purposes, and of the building of separate portions of an edifice.

c. The foundations of buildings and the means of improving the foundation bottoms.

d. Construction of ordinary buildings, as inclosures, inclined or unloaded revetments, loopholed walls, barracks and hospitals, dwelling and guard-houses, military prisons, stables, magazines, such as arsenals, wagon sheds, provision stores, bakeries, powder magazines, laboratories, communications, mines, weirs and stop-sluices, ice-breakers, &c.

e. Principles of machinery, with explanations of the forces necessary to move machines, with notice of the most common for raising and moving weights, for pumping, draining, dredging, &c.

3. The art, to apply the knowledge gained by the foregoing lectures by means of projects for certain special purposes, and under given circumstances of ground, such as his service may require of an Engineer Officer. The application of field fortification to given portions of ground is alone excepted, since the teacher of applied Fortification-drawing has this especially assigned to him, who still is only to give out his projects in unison with the teacher of Exclusive Engineering.

There belongs to this part—

a. The method of preparing plans and estimates of buildings, in the manner treated of under 2, at (*c*) and (*d*,) illustrated by frequent practice in making out such plans.

b. Practice in plans for special objects and given ground, which latter is to be chosen in the neighborhood of the fortress of Spandau.

c. Instructions generally conceived on the duties in a fortress of an Officer of Engineers, and on the practice of building in Prussian fortresses.

d. As appendix, notices on the formation and preservation of hedges, and plantations of shrubs and trees.

The time fixed for this instruction amounts in thirty-five weeks, at ten hours each, to 350 hours, which, according to the importance of the different sections, may, as a general rule, be appropriated as follows:—

Introduction and details of the first principal section, about	20	hours.
Theory of building, namely; the lectures on materials and their use,	140	"
Lectures on constructions,	80	"
Lectures on machinery,	30	"
Details of the third principal section,	80	"
Total,	350	"

The more particular distribution of this general division of time is matter of the special lesson plan, and it only remains to be observed, that with the approval of the Director, some afternoons are to be taken for viewing the most remarkable buildings in Berlin and neighborhood; and in conjunction with the

teacher of applied Fortification-drawing, three days are to be set apart for a recognizance of the works of the fortress of Spandau, relative to the projects of fortifications mentioned under 3 at (*b*.)

The two first sections of this instruction, namely, the continuation of the instruction on sieges, and the theory of construction, keep their place in the regular lectures of the school, though naturally they have an immediate applicability to practical service, and the lectures therefore ought to be made his own by the pupil by frequent exercises and detailed plans.

The projects for a given ground, on the contrary, must be worked out by the pupils in conformity with the instruction given, as much as possible independently, and as on service a young officer would do under the guidance of his superior. The drawings need not be entirely shaded, but may be partially executed by lines only, but they must be distinct and clean. Here, as in Fortification-drawing, the prescriptions of the Engineer regulation of the 25th of April, 1820, are to be observed, a copy of which is therefore always present in the drawing-room, that they may be seen by each student. Attention is to be given also to the correctness of the scale, to correct coloring, entry on the drawing of the date when done, and of the name as well as the rank of the student, as directed by the above regulation.

In the exercises all propositions for improvements which vary from the mode of practice now in use are excluded.

The teaching auxiliaries are the books and models of the school.

IV. HYDRAULIC CONSTRUCTIONS IN THE THIRD CŒTUS.

The instruction in hydraulics is to comprehend:—

1. Those general principles of hydraulic architecture which in the lectures on Exclusive Engineering in the third cœtus of the school could not be specially explained without extending them too far, and therefore were there taken for granted.

2. Such hydraulic works, as do not immediately come within the scope of military buildings, and therefore could not be included in a lecture on Exclusive Engineering, but which on account of their connection with the profession of an Engineer Officer in general, independently of military construction proper, ought to be known by him in their most important principles.

Since in the instruction in engineering in the third cœtus, opportunities offer for projects of fortification, with application of the theoretical principles given above (at 1,) the exercise problems for the instruction in hydraulic architecture need only extend to those hydraulic works (at 2,) not referring to fortification.

The instruction is in immediate connection with the lectures on mathematics, physics, and exclusive engineering, the last of which will be lectured on at the same time as hydraulics; the lectures on physics and that portion of mathematics which is here necessary, with the exception of hydraulics, have been already treated in the first cœtus. In arranging the plan of the lectures, and in carrying it out, the plans for those sciences must be considered, and conferences held with the teachers it may concern, to prevent the frequent repetition of the same subject.

The entire number of hours is seventy, two of which are given weekly,

which, that they may fall in at the same time with the lectures on exclusive engineering, are thus distributed:—

	Hours.
1. Introduction and laws of the motion of water in open channels and pipes, wells, suction and forcing pumps, about	5
2. Motion of water in streams, hydrometrical measurements,	3
3. Regulation of streams by dams, cuttings, &c., explanation of ice-floats, and of the means to prevent their destructive power,	5
4. Execution and construction of these works and of securing the banks by dikes, packing, and weirs,	14
5. Historical description of the works for internal navigation, canals, sluices, towing-paths, &c.,	4
6. Draining and irrigation works, inundations,	4
7. Harbors, moles, sands, lighthouses, roadsteads, &c.,	6
8. The principles of foundations under water, with accompanying notice of the usual pile and scoop machines,	12
9. The general principles of bridge building; historical relation of the most remarkable works executed of this kind,	17
Total,	70

To make the lecture plainer, and to exercise the student in comprehending existing hydraulic buildings, eight afternoons, at the choice of the teacher, after a previous consultation with the director, are to be appropriated to the inspection and drawing of hydraulic constructions, at Berlin, namely, the sluices and mills.

Although this instruction embraces a large field in a very short period, it must not be extended over too many objects, but rather to be confined to what is indispensable to the practical use of the engineer; the matter of these, however, to be treated fundamentally and thoroughly, and all superficiality be avoided.

The lectures are to be given from private notes, without any prescribed hand-book.

V. TACTICS.

In the First Cœtus.

The Students of the first cœtus are to receive a thorough instruction in elementary tactics, and the employment of the different arms, both separately and united. The object is not merely that they may pass the *Officer's examination*, but that they may gain true general ideas on these subjects, which ought not to be strange to a well-informed officer of any arm. A frequent illustration of the lectures delivered, by examples and problems for actual ground, is particularly recommended.

Lectures on tactics are closely connected with those on artillery, fortification, rules of the service; and in certain respects the lectures on plan-drawing and veterinary art, as well as practical exercises in surveying.

More especially—

a. In artillery: Construction of cannon, of small-arms and side-arms, choice and training of horses for artillery service: organization of the artillery; regulation for the artillery on march and in camp; use of artillery in the field, as regards the specialties of its position, movement, and mode of fighting. The use of artillery in general, in attack and defense, with the use of the reserve

artillery in more important battles, in village skirmishes, passage of rivers and defiles, and field fortifications, belongs to the lectures on artillery, but only in the second cœtus; these subjects are therefore to be treated historically with tactics, as far as knowledge of them is required for the *Officer's examination*. As a general principle, however, all the relations of detail in the constitution or the specialties of artillery are to be treated in the lectures on that science; in the tactics, on the contrary, only the more general relations which concern all the arms of the service, and where the artillery acts in union with infantry and cavalry.

b. In Fortification; the designing and construction of field-works and all means of obstruction. The manner in which ground in general, and the given position in particular, is to be used for the throwing up field-works. Attack and defense of field-works. Complete exposition of the art of sieges.

c. Veterinary art. Natural history, physiology, and general nourishment of the horse.

d. Plan-drawing and surveying. Everything that is to be said on the general physical laws of the form of the earth's surface, and specially on a knowledge of topography and its representation.

e. Rules of the service. A knowledge of military style. Discipline in all its various branches. The internal service on detachments, convoys, and separate commands, and some historical remarks on the provisioning of an army.

The lectures embrace the following principal sections:—

1. Introduction. General ideas of war. War materials. Aim of war. Conduct of war. Tactics and strategy. Army organization.

2. Organization of the Prussian army. Raising and equipping the troops. Formation and strength. Replacing of men and materials. Supplies.

3. Special ideas of tactics. Forming, changing position, and combat. Close and open fighting; distant and near fighting. Offensive and defensive. The enemy. The ground. Characteristics of the different sorts of troops. A short sketch of the development of tactics up to their present state.

4. The proscribed tactics of the infantry, cavalry, and artillery according to the Prussian regulations.

5. Ideas on the combination of the three Arms and order of battle.

6. Influence of ground on the use of troops. Classification of ground and cognizance of the individual objects on it.

7. Occupation, attack, and defense of objects on the ground, as heights, valleys, woods, river lines, farm-buildings, inhabited places, defiles, bridges, dykes.

8. Security of troops on a march. Service of advanced posts. Reconnaissances. Special duties for detachments, as escorting convoys in our own or enemy's country; foraging, surprises, ambuscades, covering of works in the field. In conclusion, some remarks on partizan warfare.

The total number of hours comprises, according to the regulation, in thirty-five weeks at four hours each, 140 hours, of which are to be employed:—

For the first and second principal sections about.....				15	hours.
"	third	"	"	20	"
"	fourth	"	"	40	"
"	fifth and sixth	"	"	15	"
"	seventh	"	"	25	"
"	eighth	"	"	25	"
Total,...				140	"

The lectures on tactics furnish the student with the positive knowledge that is necessary as a general basis; but further care is particularly taken that by the application of the problems put before the students their knowledge is not made up of mere dead knowledge, but that throughout their understandings are exercised. It is, therefore, a special duty of the teacher to frame his lectures accordingly, and as well by a development of the basis upon which the organization, the elementary tactics, and the art of war is founded, as also by very frequent exercises given to the pupils on the lectures to press towards this end.

For the solution of the tactical problems, a number of plans of ground is necessary. They are obtained on the requisition of the teacher through the Director.

It is further necessary to illustrate the use of the different troops upon the ground itself, as well for attack as defense, and to have the examples and problems given by the teachers sketched by the scholars. For such exercises four days of two or three hours each will suffice.

Of the existing hand-books, none appears perfectly qualified to serve as a basis for instruction. The filling in, therefore, of a sketch of the lectures, and of a special plan of instruction, is indispensable to give the teacher a fixed basis, and the scholars an assistance in their repetitions.

VI. MATHEMATICS.

The mathematical lecture, besides its general tendency to sharpen the intellect, is to make the scholars acquainted with all those theories and laws which are indispensable to the Artillery and Engineer officer to enable him to solve with certainty and ease those problems which so often meet him in the service.

Since these problems in part require the application of rules of the higher branches of mathematics, lectures on these ought not to be wanting, and consequently the mathematical instruction for at least a portion of the pupils must embrace (with few exceptions) the entire field of this science.

In order, however, that this demand be accommodated to the time at disposal and the capabilities of the students, the following rules are to be observed:—

1. The students of the first cœtus having already passed their examination for *Portépée ensign*, and the Predicate *ziemlich gut*, in their mathematical examination, being requisite for entry into the School, it is to be presumed that they enter with a good or at least sufficient preparatory knowledge. Still, as it is not to be expected that the necessary requirement in arithmetic and algebra will be possessed throughout, the first part of the instruction must be considered as the most important, and be given thoroughly and fundamentally.

2. Such portions of mathematics as are less necessary for Artillerists and Engineers (for instance, astronomy and the higher geodesy,) are to be entirely omitted from the lectures.

3. As even in such portions as fall within the scope of the lectures, there is much that can not be exhausted, therefore all that belongs solely to speculative views, or possibly only serves to the rounding or perfecting a system, must be passed over. The instruction in mathematics stands in near and frequent connection with the lectures on artillery, architecture, mechanics, physics, theory of surveying, and with drawing lessons, as well as with practical mensuration.

These belong specially—

a. To Artillery: architecture, mechanics; the application of all those formulas which the mathematical lectures have to deduce and to prove.

b. To Physics: the theories of dioptrics, and catoptrics, which the students require to a perfect understanding of the construction of telescopes and reflecting instruments; what is necessary from aërometry and aërostatics.

c. To Drawing lessons: practical working out of the theory of perspection, and the construction of shadows.

d. To the theory of Surveying: a knowledge of all the instruments requisite for mensuration and leveling, and the principal theorems, with their application to cases occurring in mensuration.

The lectures on mathematics form of themselves a continuous, closely connected whole; consequently, the same teacher who gave instruction in the first cœtus is to retain his pupils in the second, so that each of the two teachers commence with the first cœtus in alternate years.

For the third cœtus there will be a selection made of those students who have made themselves noticed in the second cœtus by distinguished ability, special application, and peculiar talent for the study of mathematics, and have thus raised hopes that they may be conducted with success into the higher branches of the science.

They form a separate division, whose number should always be small if the selection be guided strictly by the contemplated purpose. All the other students of the third cœtus form a second division, in which the entire field of what they have already been taught in mathematics is again gone over, with a view to its application; and at the end of this course some other subjects necessary to the Artillerist and Engineer are to be treated, without, however, mere scientific speculations.

For each of these divisions a separate teacher is appointed.

A. THE LECTURES IN THE FIRST CŒTUS EMBRACE,—

I. *Arithmetic and Algebra.*

1. Algebra, with sums, differences, products, quotients, whole numbers, roots, powers with real exponents and logarithms. The qualities of fixed numbers, fractions, decimal and continued fractions. Extraction of square and cubic roots in figures and letters, practical use of logarithms.

2. Algebra, equations of the first and second degree, with one or more unknown quantities, proportions, and the higher numerical equations.

3. Arithmetical and geometrical progression, calculation of interest, theory of combination, binomial theory for real exponents, series for powers and logarithms and analytic trigonometry.

4. Cubic and biquadratic equations, pure equation of the *n*th degree, reciprocal equations. (4½ months.)

II. *Plane Geometry.*

Similarity of figures formed by straight lines, their contents. Theory of the circle; measurement of the circle and of its parts. Geometrical analysis and application of algebra to geometry. (2½ months.)

III. *Plane Trigonometry.*

Trigonometrical functions and their logarithms. Calculation of triangles and polygons, certain parts being given. Application to the circle. (2 months.)

B. THE LECTURES IN THE SECOND CŒTUS COMPRISE,—

I. *Geometry.*

1. Geometry of solids. Place of lines and superfices in space. Solid angles, solids, determination of their superfices and contents. Applications, with consideration of the weights of material bodies.
2. Solid trigonometry, with its application to the superfices of the earth.
3. The theories of projection and co-ordinates.
4. Conic sections. (4½ months.)

II. *Statics.—Geostatics and Hydrostatics.*

With application to practical cases, namely, determination of center of gravity for ordnance and their parts, pressure upon supports, rafters, against walls, dikes and arches; stability, carrying power, strength as well as regulation and calculation of power of machines which are moved by animals. (4½ months.)

C. THE LECTURES IN THE FIRST SECTION OF THE THIRD CŒTUS COMPRISE,

1. Differential and integral calculation. (3 months.)
2. Higher geometry. (2½ months.)
3. Dynamics (mechanical,) and hydraulics, with application of the determination of the strength, direction, and distribution of the recoil upon the separate proportions of a piece of ordnance, of the science of projectiles, of the theory of carriages, of the rise of rockets. (3½ months.)

D. THE LECTURES IN THE SECOND DIVISION OF THE THIRD CŒTUS COMPRISE,

1. Repetition of the most important results of the instruction in the first cœtus in a series of exercises.
2. Repetition of the theory of statics and solution of numerous problems from real life. (3 months.)
3. Dynamics and hydraulics without higher analysis, with applications. (3 months.)

E. GENERAL APPROPRIATION OF TIME.

The number of lessons (hours) amounts, according to the prescribed plan for the first and second cœtus, to six hours, for each division of the third cœtus four hours, weekly; if the course be taken, after deducting the holidays and other interruptions, at thirty-five weeks, then there will be for the first and second cœtus, 210, and for each division of the third, 140 hours.

The number of hours to be devoted to each portion must, in the first instance, be determined by the teacher in his special lecture plan, as it in part depends upon his previous experience; at all events, all the above-named themes for the first cœtus must be treated in the stated time. Only in special cases, in the second and third cœtus, can the omission or transposition of one or the other, on reference to the higher authorities, be permitted.

It has been already remarked that the course of mathematics should impart to the students not only that amount of positive knowledge which he requires

for his immediate sphere of action and needs as incitement and guide to further study, but also should fill the important purpose of forming the mind of the students generally. This purpose will be the more certainly gained the more the teacher is enabled to render the scholar self-trusting, and in each separate study to lead to the development of a few select principles simple and easily understood, but comprising in natural and logical connection the whole theory, so that the scholar fancies they are his own discovery, and therefore prizes them as his own. The teacher must, therefore, gradually propose a series of connected inquiries, and those naturally first on which the usual systems are based, as questions to which the students have to submit answers deduced from the above-named principles, with constant application of simple common sense. By these means the students are not only continually gaining single results, made ready to their hand by use, but what is principally desired, they acquire thereby great mental activity.

As regards instruction in the separate cœtus, the following rules are to be observed:—

At the commencement in the first cœtus, the teacher should endeavor, by frequent questions to form a full and correct judgment of the previous knowledge of each student, that he may determine how he should proceed with his lecture, slower or quicker, and to what subjects generally for the entire class special notice and exercise should be devoted.

The most complete exercise of the elementary rules, forming, as it does, the indispensable basis for all future progress is in this cœtus the principal aim of the teacher.

In the second cœtus, in the application of the theory of co-ordinates to the commonest curves, no investigation of the specialties of the theory of curves is necessary, because this is reserved for later lectures, and it would here abridge the time required for subjects of nearer interest. The development of these theories must, therefore, be confined to the simplest elementary use. The study, too, of the analysis of finite numbers is to be continued only so far as the student requires for immediate application, without any intention of going deeper into the science. On the other hand, a suitably increased time is to be given to statics and hydrostatics, because the student ought to be acquainted with them in the most complete manner.

As the first division of the third cœtus consists of but few and only the best scholars, it may be required of them to work out independently at home separate questions given by the teacher, and submit them to him for examination. The progress of the student is more surely gained and advanced, the oftener he has opportunity of personally discovering mathematical truths, or by applying them to examples to come to a clearer comprehension and use of them.

In the second division the teacher will not always be able to avoid giving a repetition of the reasons of propositions. This is necessary when he perceives from the work or expressions of the students, that the majority have not perfectly comprehended the proposition. Still the teacher will here content himself with bringing forward the most important points in the chain of deduction. The explanatory problems are solved by the teacher himself, who then sets similar ones for working out by the students at home.

For practical static problems, the teacher can use with great benefit objects often occurring in common life, and yet regarded so little; the numerous appli-

cations of the lever, of the inclined plane, &c., by artillerists and engineers, for their works, carriages, draught, &c., furnish sufficient material for such problems; as for instance, determination of the depth of a boat of given length and breadth when after putting into it a piece of ordnance a given height out of water is required; determination of the power requisite to overcome the resistance of a log lying in the track of a vessel; determination of the pressure of a laden beam on two or more supports with reference to the flexibility of the beam; determination of the center of gravity in an excentric hollow shot, both theoretically with given radius and known centers, as well as more practically when the centers and the radius of its interior are unknown, as by dipping the hollow shot into quicksilver; determination of the counterpoise of a drawbridge and examination of the best position for the axle; investigation of the strength of metal and wood pipes which are to serve as water-pipes at given heights of pressure, &c.

At the same time the teacher ought not to leave unnoticed the advantages which theory can offer to practice when rightly applied, by which is in no way meant that the practical man should enter every time into a prolix and anxious calculation, but from the improvement his mind and capacities have received, he may apply readily what he has learnt to the purposes of common life.

Dynamics and hydraulics will be rather treated in a physical and historical point of view; here, too, the application of known professional results is the principal object.

As the limited time will not allow separate mathematical repetitions, the teacher should therefore be the more careful to make his lectures as much as possible applicatory. To insure progress the students must, besides the usual writing out the lecture, have frequent themes given to them for work at home, and of which their own execution should be secured by proper means.

It is perfectly necessary that a hand-book should form the basis of the instruction, from which the teacher should lecture, and the students make repetitions.

The hand-books are to be proposed by the teacher to the Board of Studies, and must not be changed without permission.

These books, as well as the logarithm tables, every student must have a copy of, as he can not do without them in the school, and may frequently require them in future life.

Models of solids, to illustrate the projection theory, are in the collection of the models of the school.

VII. PRACTICAL ARTILLERY EXERCISES.

The practical artillery exercises are intended, in the first place, to furnish the students with a sight of that portion of the material of the artillery which they have had no previous opportunity of knowing, and of which the knowledge is indispensable for a complete understanding of the theoretical lecture. The exercises should follow the lecture as immediately as possible, and occur therefore during the continuance of the theoretical course.

The students are besides to become acquainted with the methods of execution of the most important artillery duties, in an extent compatible with their position, and the time at their disposition. For this portion of the exercises, the months of July, August and September are to be preferred.

In the major part of these exercises, the engineer students take part, so as to gain a knowledge of such parts of the artillery service as seem to be of the greatest importance to them.

The artillery exercises separate into numerous subdivisions, of which the following may be particularly remarked:—

I. EXERCISES OF THE FIRST CŒTUS.

A. *Visits.*

The visits happen, as already noted, at the period of the theoretical instruction. The students are to be divided into as many sections as is necessary, that each may gain the desired information. There belong to this part—

a. Visiting the foundry and the boring machine. All the students of the first cœtus are to be taken by the artillery teacher of this cœtus, on two afternoons, to the foundry, and to the new boring machine.

They will see the general construction of the foundry and the boring machine, and, in case such work is going on, the molding, boring, and turning, and receive the explanations necessary.

b. Examination of ordnance, gun-carriages, and ammunition wagons.

Those in the arsenal, as well as the exercising pieces of the regiment of artillery of the guard, are to be used for this purpose, to exhibit the construction of ordnance both in the Prussian and foreign artilleries, and also those of an earlier date, from the specimens kept there. In the same way as has been remarked for the ordnance, the gun-carriages and equipages of the guard artillery regiment in store will offer opportunity for a more exact scrutiny of these carriages, limbers, and wagons. For these visits four afternoons are to be taken.

c. Visit to the workshops of the artillery:—

The students will, in two afternoons, gain there a knowledge of the following objects:

1. The mode of work in general.
2. Processes in the manufacture of the most important objects of artillery material, as axles, wheels, carriages, mountings, sponges, harness, ropes, &c.
3. The raw material (wood, iron, leather.)
4. Objects furnished to field, siege, and fortress artillery.

d. Visit to the small-arms factory and powder-mills in Spandau:—

The scholars of the first cœtus will be conducted into both manufactories, to obtain a general insight into the various works.

In order that the work of the manufactories may receive no interruption, the teacher of the first cœtus is to communicate beforehand with their respective superintendents, and take the students in suitable small parties, and before entering the powder manufactory to insist, most carefully, on all the proper precautions being observed.

These visits are to take place during the theoretical course on the same day as is fixed for the first cœtus to visit the fortress of Spandau to study its fortifications; and, therefore, an agreement should be made between the teacher of artillery and the teacher of general engineering.

e. Visit to the armory at the arsenal:—

The students are to be conducted on an afternoon to the armory of the arsenal, where the superintendent will explain to them the peculiarities of match

and wheel locks, with the most remarkable projects for loading at the breech, and with the form of small arms amongst other nations.

B. *Exercises.*

a. Examination of small arms:—

The students are to be taken by their teacher to the musket manufactory, where they will be shown the mode of proof of small arms in general, and with reference to the theoretical lecture then in progress.

Each student then receives a faulty musket, with direction to examine and note its defects. The teacher revises and corrects these notes.

b. The management of machines:

In the presence of the students the management of various machines, &c., as well as the repair of damaged carriages, will be undertaken. According to the means at disposal, such exercises will be selected as are most instructive, in exhibiting arrangement, strength, and care in their application.

The students will be permitted to lend a hand only in such cases as it is foreseen that their strength will be sufficient. For all other purposes where strength is necessary, workmen must be employed.

II. EXERCISES IN THE SECOND CURSUS.

When the teacher judges proper, some of the previous visits are repeated on the afternoons disposable during the theoretical course.

A. *Marking out and Tracing Batteries.*

The students undertake these exercises under inspection of their teacher of artillery on two days in the last three months of the course.

The teacher instructs them then how to ascertain the prolongation of the enemy's lines, and the mode of determining the line of fire of the first embrasure of the different batteries, as well as the other points to be marked out, both with the use of the usual instruments, and with simple measurement by pacing, and laying down right angles by the eye.

A complete construction of a battery is not possible on account of the shortness of time, paucity of means, and strength of the students. The exercise, therefore, is confined to an explanation of the formation of the material and tool depôts; to marking out and tracing horizontal and sunk batteries on even, irregular, and sloping ground, and to the construction of the powder magazine.

B. *Practical Exemplification of the Rules for Placing Ordnance according to the Ground.*

These exercises are to be carried out on two afternoons by all the students, under the inspection of their artillery teacher.

They have only reference to the ground, and leave out of consideration all tactical considerations. This object may be fully attained even without guns, and the necessary instruction may be given without them, as it would not be easy to form all the batteries in the desired number.

The teacher chooses the ground, explains it by means of a plan to the students, and goes with them to the place. He divides them into various sections, and lets each select positions for from two to eight pieces, both for attack and defence with different kinds of ordnance, giving only generally the direction and distance at which the enemy is operating.

Each position is inspected by the teacher, and the views and reasons for it received and discussed as regards effect, mode of firing, and covering and free movement, and where it is necessary, improved; and at the same time the requisite precautions taken for the limbers and wagons.

C. *Drawings of Ordnance Carriages and Wagons.*

These exercises are to be undertaken by the artillerists of the second cœtus, under inspection of the teacher of artillery-drawing, on twelve afternoons in June.

The drawing of a piece of ordnance is to be clearly distinguished from the examination of it. For the first, taking the necessary measures is alone necessary, but not their comparison with given models.

The teacher will order these exercises, so that the students learn principally—

1. What scale they ought to take for a given object, so as to execute a drawing with the precision necessary for being afterwards worked from.

2. With what instruments and method of procedure they may most easily obtain their end.

3. How notices of improvements are to be taken and arranged.

4. How the rough draft is to be jotted down.

It must be here particularly remarked that our guns, carriages, &c., have no mathematically exact forms, and that therefore the number of measures to be taken must be often multiplied to have a true figure of the body.

A fair drawing from these measures in the above period is so much the less possible, as the number of objects is as much as possible multiplied. It is fully sufficient, however, for the purpose of this exercise, that the students learn to take complete and useful rough drafts.

On their entrance into the third cœtus, the complete drawings from these rough drafts take place.

In his selection of objects to be drawn, the teacher must, in having regard to variety, take care that the drawings by too great difficulty do not exceed the time and power of the students, nor by too great simplicity cease to be instructive.

Ordnance carriages, limbers, wagons, and the machines required in artillery, are the most suitable for choice, and are easiest obtainable in the arsenal.

The students must be divided into sub-sections, of at most three or four persons, and to each a separate task given.

The teacher is to be present at the drawings to see to their proper execution, and has delivered to him the notices and rough sketches to amend any errors that may be in them.

The relative section of the second edition of Burg's "*Drawing of Artillery Material*" is to be taken as the basis for these exercises. In addition to them, the students receive guidance and suitable instruction in drawing artillery objects off-hand by the eye, without the use of instruments. The first two days are to be chosen for this, and the students by this use of off-hand drawing receive at the same time a useful preparation for the drawings subsequently required to be taken by the aid of instruments.

D. *Exercises necessary in regard to Sieges—*

Are to be conducted by the teacher of artillery and special engineering jointly, and are given more in detail under *exercises in fortification.*

III. EXERCISES IN COMMON OF THE FIRST AND SECOND CŒTUS.

A. *Proof of Powder.*

This exercise is to be conducted by all the students of the first and second cœtus at the time of the gun-practice, and comprises—

1. Firing different sorts of powder from the proof mortar.
2. Firing different sorts of powder purposely brought into an abnormal state.
3. Instruction in weighing and measuring the powder.

B. *Artillery Practice.*

All the students of the second and third cœtus take part in the practice under the inspection of the two teachers of artillery, for which fourteen days in August and September are fixed. If possible, it is to be undertaken in the morning, and only when the practice-ground is otherwise occupied is it to be deferred till the afternoons.

The practice comprises—

1. The necessary preparation for firing; namely, laying down the platform, marking the range, fixing the targets, preparing the lists to note the shots.
2. Firing from different kinds of ordnance and with different projectiles.
3. Instruction of the students in the service of the guns; selection of the charge and direction under given circumstances, and their correction; effects of distance; noting and jotting down the shots and the time of flight; calculation of the length of fuse, of ranges and averages from the different data, and remarks on the effects sought.
4. Burning a portion of prepared laboratory materials for observation of its action and effect.

The following are to be objects of practice:—

a. Rounds of six, twelve, and twenty-four lbs. shot and shell out of the short 24-pounders, to note—

aa. The grazes, distances, and deviations at different elevations, and as regards ricochet fire.

bb. Probability of hitting upright targets at various distances.

cc. As regards dismounting.

dd. As regards firing against heads of saps.

b. Seven, ten and twenty-five lb. shells, carcases, and light balls, to note—

aa. The grazes, distances, and deviations at different elevations and charges, also as regards ricochet firing.

bb. The probability of hitting upright targets at various distances.

c. Shells, carcases, and light balls from mortars, to note—

aa. The probability of hitting upright targets at different distances.

bb. The calculation of the charge or elevation when one of these elements and the distance are given, or *vice versâ*.

cc. Calculation of lengths of fuse for given distances.

d. Throwing hand grenades, stones, 1-pound case shot, and 3-pound balls at various distances for comparison of the effects.

e. Firing from the hand and stock-mortars at differing distances.

f. Case shot from 6 or 12-pounders, also from short or long 24-pounders and 7 and 50-pound howitzers at different distances against planks, and both with case shot, and grape shot, for observing the effect:

aa. Of different charges.

bb. Of different weights of the entire case.

cc. Of the weight and size of balls used.

dd. There is also to be observed the scattering, the number of hits and wide balls, and determination of the best line.

g. Shrapnel shells from field-pieces against planking.

5. The number of the before-named rounds is not to be too great, partly not to increase expense, partly in regard to time, since the practice is intended for instruction, and therefore not to be hurried. Still for shot, shell, and grape shot, ten rounds is the *minimum* if a result is to be drawn; for the small mortar five rounds are sufficient.

Notwithstanding this limit, it will not be possible to take the practice all in one year. It seems, therefore, expedient to divide the whole into two portions, so that the most important practice happens indeed in each year, generally however, in one year the practice is to take place with field-pieces, in the following year with siege-pieces, so that the student who is present once in the first year and once in the second can complete the necessary course.

The teachers have, therefore, to determine, in the proposed plans for these exercises, the sort and number of rounds they judge necessary for the following year.

C. *Practice in the Laboratory.*

As the students of the artillery, by the present regulations of their education in the regiments, have not sufficient opportunity to learn the service of the laboratory perfectly, particular attention must be paid to this work in the school.

The students of the engineer corps also take part in it, in the second cœtus, not to become perfect proficients in the different operations, but so as to gain a general knowledge of ammunition, matches, and compositions, and the duties of the laboratory.

All the students of the first, and the artillery students of the second cœtus are therefore to be occupied by their teachers for twelve afternoons in the laboratory.

For the superintendence, so necessary in these works, and for variety of practice, the fireworkers employed as assistant teachers in the school, and others from the proof department of the artillery, and also five or six artillery officers of the third cœtus, are to be present at this practice, so that each of these students is present twice or thrice on the average.

The work embraces, first, the preparation of ammunition for the artillery practice, &c.

But as this would not suffice for the complete instruction of such a large number of students, it must receive an extension calculated for this purpose and embrace not only the separate preparations, but also a large quantity of ammunition, which, as not required for the school, is therefore sent to the depôt.

The following work is to be preferred:—

Pounding of saltpetre, grinding meal powder, pounding sulphur and charcoal, boiling paste, making mastic, composition, quick-match, fuses, tubes, portfires, carcass composition, touchpaper, case and grape shot, loading shells for bursting, discharging empty shells in which a fuse only has been driven; carcasses, fire-balls, and light balls; infantry, cavalry, buck-shot, and percussion

cartridges; ball, canister, howitzer, and paper cartridges. Fanal, signal rockets, pitch compounds, powder bags, and stink-pots. The teacher is to make a careful distribution of the students, (allowing for such as have missed any days by illness,) to be satisfied that each artillerist has made every article in the laboratory, if possible, or at least has carefully witnessed its preparation.

IV. EXERCISES IN THE THIRD CŒTUS.

All the exercises of this cœtus take place during the period of the theoretical course.

A. *Visit to the Workshops.*

The student will have to learn the mode of proceeding, the construction, and the use of the machines employed. Examination and storing of the most important raw materials.

B. *Visit to the Iron Foundry.*

All the students of the third cœtus are to be divided into two sections, and each section to be conducted on an afternoon under the care of the teacher of artillery concerned to the Royal Iron Foundry.

They will see there the molding, casting, and cleaning of case shot, cannon balls, and shells.

They will also have explained to them the construction of reverberatory and cupola furnaces, of steam engines, and of turning lathes, and planing benches.

C. *Visit to the Foundry and Boring Machine.*

The students of the third cœtus are to be present at the actual manufacture of cannon, their molding, casting, and boring. But as the circumscribed room and other considerations will not allow all the students to be present at one time, different divisions are to be formed, to visit the foundry and boring house on different days. The teacher concerned, will, therefore, make the necessary inquiries as to the time when the above works are going on, and arrange the visits by communication with the director.

The casting and preparation of iron ordnance require particular attention. On this, too, the teacher has to obtain information, and proceed as above.

D. *Examination of Iron Ammunition.*

The artillery officers of the third cœtus take these exercises in hand on two afternoons, under care of the artillery teacher in the same cœtus.

The purport of it is not so much a thorough instruction in this manufacture, as a completion of the theoretical lectures on the mode of conducting the processes by means of personal inspection and handling of the instruments. The teacher will pay particular attention to the errors that may occur in the measurements, &c.

E. *Examination of Cannon.*

This exercise is to be undertaken by the artillery officers of the third cœtus, under the inspection of their artillery teacher, in six afternoons. The object of it is exactly the same as of the foregoing.

The exercise must commence with directions for proving the instruments, when the teacher will show the mode of their manipulation.

As the use of such instruments only can be reckoned on as the school, the depôt, and the artillery proof department possess, only three sections of the

students can work each day simultaneously; the section consisting, at the utmost, of six persons, if individual handling of them is presumed necessary.

The teacher must, therefore, divide the students into sub-sections, and make such arrangement that each student, if possible, personally work every part of the exercise, or at least have a perfect sight of it.

That portion of the students which can not be immediately occupied on each exercise day, put their tables of dimensions in the order and forms required by the regulations.

F. *Examination of the Gun-Carriages and Wagons.*

The exercise is to be conducted by the artillery officers of the third cœtus, exactly as the foregoing, in five afternoons.

G. *Practical Exposition of the Rules for the placing of Guns according to given Tactical Relations.*

These exercises are to be performed by the artillery students of the third cœtus, under the direction of their teacher of artillery, on four afternoons.

The teacher makes known the ground by means of a plan; he then directs reconnaissances to be made, and receives the reports.

He selects a tactical problem, the nature of which offers opportunity to remark both on the placing of guns of different calibres, and also the reserve artillery at the decisive moment of a battle, as well as the more minute details of placing single divisions and guns, and the limbers, riding horses, and wagons.

Before he solves himself the problem completely, he gathers the opinions of the students in respect to single portions, and if necessary sets them right.

The principles to be followed refer so specially to the ground, that the object of illustrating the instructions can be attained without guns. The teacher may therefore content himself with marking by flags the situation of single guns and batteries, by which the advantage is obtained of an easier use of the ground.

II. *Exercises at Spandau in reference to a Siege.*

These exercises are to be conducted by the teacher of artillery, in unison with analogous regulations of the teacher of engineering, and are more particularly mentioned in the practical exercises of fortification.

The limits of time and means render it impossible to gain for the above-named exercises that extent by which the full acquirement of the necessary mechanical readiness could be insured. It is sufficient if the student has made a perfect personal examination and performed as much manipulation as circumstances permit.

The separate practical exercises can only be made after the termination of the theoretical treatment of the subject. This rule is necessary, partly because this practice is only a continuance and completion of the lecture, partly because the shortness of time restricts the exercises considerably, and therefore the days devoted to them can not be applied to theoretical explanations, which will be more profitably given in the lectures.

Where the nature of the exercises permits, the officers and elder *portépée ensigns* will take the superintendence, that having formerly learnt the execution, they may now make themselves acquainted with the duties of ordering and inspection.

The number of students engaged at one time in an exercise ought not to be so large that a portion of it remain unoccupied or not under the complete inspection of the teacher. The disturbances that occur too easily in such cases, being most injurious, must be most carefully avoided. The teacher will make the division above stated, and take all necessary measures for obtaining the requisite control.

If, at any of the exercises, danger can arise to the students, the teacher is previously to instruct them specially in what is to be observed for the safety of the workmen; after that, the superintendence of the students must be conducted with increased care, and any departure from the given orders visited with redoubled severity.

The determination of the days for these exercises rests with the director, after consulting the teachers. Should unexpected hindrances prevent the carrying out an exercise, the teacher may determine concerning it, but must consult with the Direction as to the fetching it up on another disposable day.

The necessary workmen will be demanded by the Direction from the respective services, of which the teacher will give to the Direction due previous notice.

The guns necessary for practice are to be lent by the Artillery Regiment of the Guard and the Artillery Depôt; all the other instruments, equipments, &c., are borrowed from the Depôt. All materials are received by order of the war department or by purchase. It is therefore the business of the senior of the two Artillery teachers, in his yearly demand for the practice, to state the full requirement of tools and materials, that the Direction may take timely measures for their supply.

VIII. PRACTICAL EXERCISES IN FORTIFICATION.

Practical exercises in fortification stand in immediate relation to the lectures on fortification, sieges, and field engineering. They complete, as far as possible under given circumstances, the theoretical lectures by personal view; they also offer the students opportunity for solving fitly chosen problems, to apply what has been learnt, and to prepare by reflection for practical service.

The exercises are to be conducted in each cœtus by the teachers who lecture on Engineering. The presence of the Artillery teacher is elsewhere separately noted.

A. THE EXERCISES COMPRISE—

a. *For the First Cœtus.*

1. In unison with the teacher of Artillery and of General Engineering, the examination of the fortress of Spandau, to make clear to the students the combination of the details of a complete fortress from an actual example.

2. Examination of the models of fortresses and their details in the Arsenal, to make clear the principles of a siege.

3. Visiting the exercising-ground of the Engineer division of the guard in all its details.

4. Marking out, tracing, profiling, calculation of the cubic measurements, of the time for building, of the number of workmen, and of the garrison for given fortifications on ground near Berlin.

5. Being present at the exercises of the Engineer division of the guard in sapping, mining, building redoubts, laying bridges, and their instructions.

b. *For the Second Cœtus.*

1. Examining the models in the model-house, partly to illustrate the systems taught, partly to show the influence of ground on the situation, form, and contrivance of the works; and again to explain by the aid of the necessary notices of the sieges of these fortresses the choice of the fronts of attack, and other matters relating to sieges.

2. Problems on the ground for sieges, such as may happen, to a subaltern officer, as simple as possible, but to be solved clearly and exactly.

These exercises refer principally to the marking out of parallels, zig-zags, and saps, as well as marking out and tracing siege batteries. They are to be undertaken under the united direction of the teachers of Special Engineering and of Artillery on the exercise ground of the Guard Engineer division.

3. Problems on field fortification, not too comprehensively drawn out, but of which the solution should be the more complete. Here belong, *e. g.*, the fortifying of a house, a farmstead, a bridge, or other defile, covering of an advanced post, &c., &c.

c. *For the Third Cœtus.*

1. For the Artillerists:—Exercises in reconnaissances of fortresses. Fixing the points for laying down batteries of attack. Statements of the arming of detached works against *coups de main* and formal attacks. Sketches of instructions for subordinates in particular cases. Construction of ammunition and other depôts in and before a fortress. Under the guidance of the Artillery teacher of the third cœtus, with regard to the analogous regulations of the teacher of Exclusive Engineering.

2. For Engineers:—*a.* Reconnaissance of Spandau in reference to projects in permanent and field fortification, as well as military architecture and hydraulic works, under the guidance of the teacher of Exclusive Engineering, with the assistance of the teacher of Fortification-drawing.

b. In conjunction with the Artillerists, reconnaissance of Spandau for fixing a front of attack, securing its investment by field fortification adapted to the ground. Placing the depôts of material. Marking out the first parallel, with its communications, as well as the subsequent works of attack. Measures of the defenders, special discussion on arming the works on the spot. Under the guidance of the teacher of Exclusive Engineering, having regard to the analogous regulations of the Artillery teacher in the third cœtus.

B. FIXING AND APPORTIONING THE TIME.

a. *For the First Cœtus:—*

1. The visits prescribed in 1 and 2 for this cœtus are to be made in spring, whilst the theoretical course is going on, and for them are fixed,.....	2 days.
2. The further exercises under 3, 4, and 5, are to be taken in the summer months; to them are allotted, for the visit at 3,....	1 "
To the exercises at 4,.....	5 "
To " at 5,.....	6 "
Total,.....	14 "

b. *For the Second Cœtus:—*

The exercises under 1, 2, 3 for this cœtus, are to be held in the Summer, and are thus regulated:—

For the visit at 1,	2	days.
To the exercises at 2,	2	"
To " at 3,	8	"
Total,	12	"

c. *For the Third Cœtus:—*

The exercises ordered for this class are to take place only in Spring, whilst the theoretical instruction is going on, and for it are fixed:—

1. For exercises by the Engineers alone,	2	days.
2. For those jointly by Engineers and Artillerists,	3	"
Total,	5	"

The days of the calendar for these exercises are to be proposed by the teachers when delivering in their annual sketch of exercises, and their propositions will be laid by the Direction before the authorities for their approval.

To engage the pupils to work they are to be divided for the visits and exercises into suitable sections. Each section receives its problem from the teacher, who also nominates the president of the section. This president distributes the sub-sections among the other students, and sees that the work to be written and drawn is finished in the required time, signed by the author, and is delivered by him to the teacher. Great care is to be taken that single students do not remain unoccupied; the disturbances thence only too likely to arise are always injurious to the instruction and the discipline. In giving out problems, their principal conditions only are to be designated by the teacher, and the development left entirely to the student, or with little aid from the teacher, in order that the student may gain early that confidence and independence necessary to the soldier in carrying out matters committed to his charge.

In the exercises the workmen demanded for marking out, are to be limited as much as possible, as the students must perform the greatest part of the work themselves. The number indispensably necessary will be demanded in time by the teacher from the Guard Engineer Division through the Direction.

The necessary material, if the Guard Engineer Division can not furnish it as a loan, may be purchased at the charge of the school.

THE WAR OR STAFF SCHOOL AT BERLIN.

BY GENERAL VON HOPFNER.

I. OBJECT, PLAN AND STAFF OF THE INSTITUTION.

The War School (*Kriegs-Schule*) is intended to receive officers of all arms, who during three years of active service have given proof of ability and of particular capacity. They find there the means for acquiring the knowledge requisite for the higher ranks of the service, for the duties of officers of the staff, and for all other appointments which demand military and scientific studies of a higher and more general character than the common ones.

The course of study is for three years, and is divided amongst three classes. The courses begin on the 1st of October, and continue to the 1st of July. The number of officers who can be received is 120, neither room nor means of instruction sufficing for more. The three months of vacation in the summer are employed by the pupils in learning the service of those arms of the profession to which they do not belong.

The Special Direction of the War School consists,—

(*a*) Of the Military Direction.

(*b*) Of the Direction of Studies.

The Military Direction consists of a director, a field officer connected with the direction as inspector, and an adjutant, who directs the accounts of the Institution.

The military director is supreme, both over the military officers who are members of direction, and of the military officers who are studying in the school. The police, the discipline, and all the administration of the Institution are under his control. All the subordinate officers in the house are under his orders. The field officer attached to him is charged to look carefully to the discipline and to the due attendance at the lectures. The adjutant directs the correspondence and accounts of the establishment. The whole of the staff and the military directors are lodged in the school.

The Direction of Studies is in the hands of three field officers of literary and scientific attainments, and of two other persons, civil-

ians of Berlin, of high literary reputation. Its president is the senior officer, who is generally also the military director. It has also a secretary attached to it.

The Direction or Board of Studies is exclusively intrusted with the care of everything affecting the teaching of the Institution, and its members are bound to be frequently present at the lectures. It has also under its inspection all the means and objects required for teaching, such as the library, the collection of maps and models, the collections for physical science, and the laboratory.

The Director of Studies selects the professors of the Institution, recommends them to the superior authorities, and in case of their appointment gives them their instructions.

At the beginning of each course the direction fixes the plan of the lectures, and if any alterations in them are required, proposes them to the superior authorities for their sanction.

The Direction of Studies regulates the examinations which the officers who are candidates for admission into the school are to undergo. With this view it draws up a certain number of subjects and questions suited for the purpose, which it sends, in the spring of each year, to the chiefs of the staff of the different Corps d'Armée, in whose presence the candidates do their work. Those of the candidates whose work is satisfactory are entered at once in the school.

In order to take account of the progress of the students the board of studies makes them pass an examination in writing at the end of every three months; makes a revision of the judgment of the professors upon the papers, and conjointly with the military board of direction, gives certificates at the end of the triennial course to the officers who have gone through it completely. In these studies it is the part of the board of studies to give a judgment on the scientific merit, and that of the military board to judge the moral conduct of the officers.

The two boards make a report yearly on the progress and the conduct of the officers of the school. This report is submitted to the king by the minister of war. Particular mention is made of those officers who by extraordinary success have deserved his majesty's favor.

II. SUBJECTS AND AIDS OF INSTRUCTION.

Attendance on the different courses is partly obligatory, partly compulsory, with this restriction, however, that every student must attend twenty lectures a week, given before 12 o'clock, including the obligatory courses. These last are those of the purely military

sciences, and for the first class those of mathematics. As it is impossible for most of the pupils to give sufficient attention to all the courses to be examined in them at the end of each three months, they are allowed to select those of the courses which they may choose to follow. But this choice once made must be adhered to.

The instruction is divided into theoretical courses and practical exercises.

The theoretical courses comprehend all the subjects which come within the object of the Institution. They are the following:—

1. Mathematics, a course of three years, six lectures a week, half employed in statement of the theory, half in the practical application.
2. The Higher Geodesy, in the third class, three lectures a week.
3. Physical Geography, in the first class, two lectures a week.
4. General Geography, in the first class, four lectures a week.
5. Special Geography, particularly that of the probable theaters of War for Prussia, in the second class, four lectures a week.
6. Universal History, in the first and second class, four lectures a week in each.
7. General History of Literature, in the third class, four lectures a week.
8. Logic, in the second class, four lectures a week.
9. Physical Science, in the second class, four lectures a week.
10. Chemistry, in the third class, four lectures a week.
11. Physiology of the Horse, in the second class, two lectures a week.
12. Tactics, in the first and second classes, four lectures a week in each.
13. Artillery, in the first class, three lectures a week.
14. Fortification, a course of three years in the three classes. In the first class, Field Fortification; in the second, Permanent Fortification; in the third, the Conduct of Sieges; two lectures a week in each class.
15. Military Administration, in the first class, two lectures a week.
16. Military History, in the third class, seven lectures a week.
17. Duties of the Staff, in the third class, three lectures a week.
18. Military Law, in the third class, one lecture a week.

All these lectures are given in the morning, between eight and one o'clock.

19. The French Language, a course of three years in different classes; into each of which the pupils enter according to the knowledge they possess of the language; six lectures a week for each class.
20. The Russian Language, four lectures a week.

The above two courses are in the afternoon.

The practical work is done after the end of the courses of the second and third classes. They consist in making the officers draw plans for military objects, make sketches of ground.

These exercises are completed by a journey of fifteen days under the conduct of an officer of the staff, in order to teach the service of an officer of the staff in the country.

The instruments of teaching consist of—

1. A library for the use of professors and students, and a collection of maps and plans, all under the charge of a librarian living within the school.

2. A collection of models for the courses of artillery and fortification, under the care of a commissary of the school.

3. A cabinet of physical science, under the direction of a professor lodged in the house.

4. A laboratory and chemical apparatus, under the direction of a professor of chemistry.

There are no manuals specially used for the instruction.

For the courses of geography and of the history of war, the direction furnishes the pupils with the plans and maps required, as far as the means of the Institution allow it, or it procures them at moderate prices, to be repaid by instalments.

PROFESSORS AND STUDENTS.

The officers acting as professors in the school are officers of mature age, and high education, chosen from the garrison of Berlin. The teacher of the duties of the staff, must always belong to this corps. They are appointed to their work in the school for an indefinite time, without prejudice to their other duties.

The civil professors are generally chosen from those of the Royal University at Berlin.

With regard to discipline, all the professors are subject to the board of military direction; with regard to teaching, to the board of direction of studies.

Every professor is bound upon entering on his functions to lay before the board of direction of studies a programme stating the bearing, the successive subjects, and the arrangement of his course. This programme must be approved by the direction.

The payment of professors is fixed according to the number of their weekly lectures. It is less for the professors of Language, as they require less time to prepare their lectures.

The students of the school are under the immediate authority of the military direction; but they are ordered to look upon the professors, whilst engaged in their duties, as their superiors, so that offences against them are subject to military law.

Permission to follow the courses of the school involves for every officer the obligation to serve two years in the army for every year passed in the school.

Although the complete course is for three years, officers do not always continue it for more than one year. At the end of the year those only are allowed to return who have shown themselves deserving of this favor. Students lose the right of continuing their studies who neglect their lectures, or show indifference and a want of interest in their work, who come often too late, avoid the duties imposed upon them, or endeavor to escape their examinations.

Any ill conduct, or even want of capacity to continue a sedentary life, or any inaptitude for the branches of the service distinct from their own, shown in the part they take in them during the summer, are also disqualifications.

At the end of every annual course the boards of military direction and of studies meet together, to fix, in accordance with the preceding paragraph, the list of officers who have gained the right of returning to the school.

At the beginning of the courses the students must give notice as to which of the voluntary courses they mean to attend. After this notice, such courses are regarded as obligatory, and no dispensation from them can be obtained.

At the end of the course of each year, the officers are allowed to ascertain the judgment given upon their work in the three-monthly examination by the professors.

Other points relative to the students are the subject of special regulations.

An employé of the house, called the commissary, is charged with the surveillance of the buildings of the school and the furniture belonging to it. He has to look after its security, order, and cleanliness. He must take an inventory of all things belonging to the house.

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